DISCOVERY

Monthly Notebook
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Far and Near

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The Koala of Australia, one of the six hundred mammals close to extinction.

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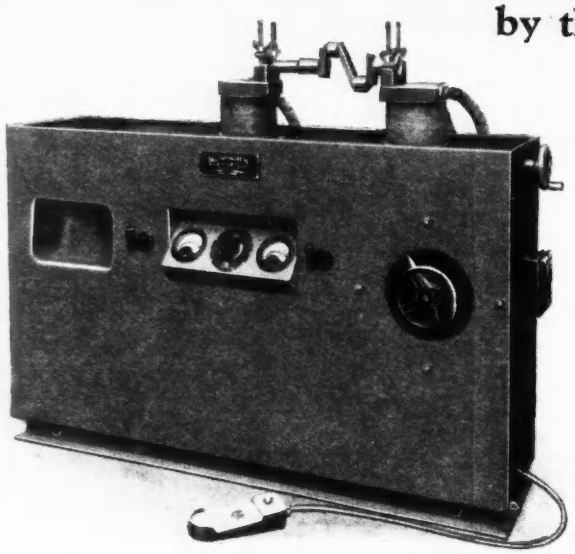

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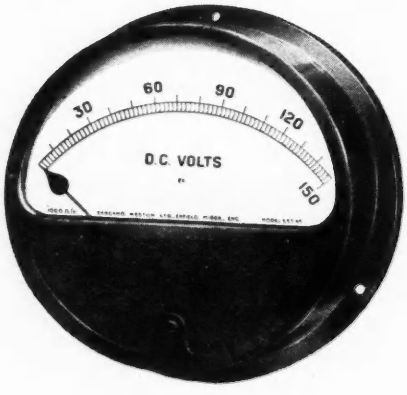

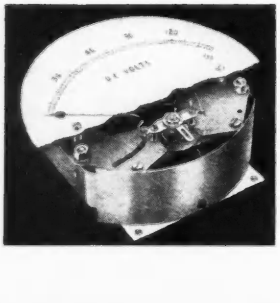

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DISCOVERY

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The Progress of Science

Animals on the Edge of Extinction

MANY good ideas which before the war were hastily dumped in the category of 'revolutionary' and categorically dismissed without examination gained acceptance during the years 1939–45. By the end of the war a great many such ideas had been built up into detailed schemes and incorporated into our post-war ambitions. For instance, the world emerged from the most destructive war in all history more conservation-minded than ever before: it was evident that, in future, waste of natural resources on the pre-war scale would not be tolerated.

Among Britain's post-war plans were practical schemes for protecting our wild-life resources. These schemes were not officially inspired; they were produced by far-sighted naturalists, scientists, and country lovers, whose ideas found collective expression in the reports of such bodies as the Nature Reserves Investigation Committee (see DISCOVERY, January 1946, Vol. 7, No. 1, pp. 9–14). If these schemes did not exactly set the Thames on fire at Westminster, they did sufficiently impress an adequate number of conservation-minded politicians who were able to persuade the Government to accept its responsibility for wild-life protection.

On the other side of the Atlantic attention was being directed more to the *world* problem of wild-life protection, the national problem being already under constant surveillance by the Wild Life Service and the U.S. National Park Service, which know what to do when it becomes apparent that a native species is in need of protection. Nature conservation within the United States has long been in experienced hands.

So Americans are freer than most people to devote attention to international conservation problems. One focus for such work is the American Committee for International Wild Life Protection, which has recently published two books,* bringing home the urgent need to protect 600 forms of mammals which are in danger of extinction.

* *Extinct and Vanishing Mammals of the Western Hemisphere.* By the late Dr. Glover M. Allen.

Extinct and Vanishing Mammals of the Old World. By Dr. Francis Harper.

These are respectively Special Publications, Nos. 11 and 12 of the American Committee for International Wild Life Protection, New York Zoological Park, New York, 60, N.Y.

The man who said "the greatest tragedy in Nature is the extinction of a species" was not exaggerating. The past 2000 years has witnessed the disappearance from the earth of 106 forms of mammal. (Some of the forms were subspecies of species that still survive, but the number of species lost through extinction is nigh on eighty.)

The rate of extinction has been accelerated in recent times. Dr. Harper states that the past 100 years have seen the passing of about 67% of those 106 extinct forms. In the past 50 years approximately 38% as many forms have been exterminated as in all previous recorded history.

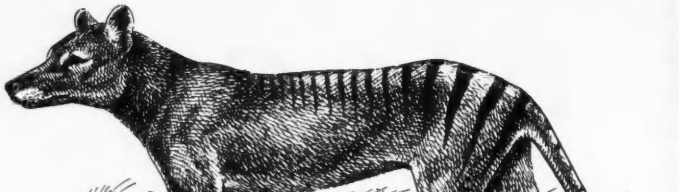
"*It is well within the bounds of possibility that during the next hundred years we may be extinguishing this group at the approximate rate of one form per year,*" *warns Dr. Harper.*

Among those in danger of extinction are many of the species that most interest scientists and naturalists. For example, the whole unique marsupial fauna of Australasia is threatened, particularly the smaller species within it. This fauna, which is of absorbing interest because of the fascinating examples of parallel evolution it provides—it has its counterparts of the rat, rabbit, dog, mole, ant-eater, etc.; only marsupial whales and marsupial bats are lacking—has the great weakness of a typical island fauna in that it cannot cope with the more efficient mammals such as rabbits, foxes and domestic cats and dogs that have been introduced.

The largest of the marsupial carnivores, for instance, is approaching extinction; this is the Tasmanian Wolf (*Thylacinus cynocephalus*), which is also known as the Thylacine and as the Stripe-bottomed Fox. It used to occur on the Australian mainland, but there it could not stand the competition of the Dingo—which is either an indigenous dog, or a tame dog which was introduced many centuries ago and today runs wild. The Thylacine is now found only in Tasmania, and here it has been so relentlessly hunted because of its destructiveness towards sheep that it has been driven into one mountainous refuge on the West Coast. It is now fully protected by law, and its last refuge seems likely to become a recognised sanctuary.

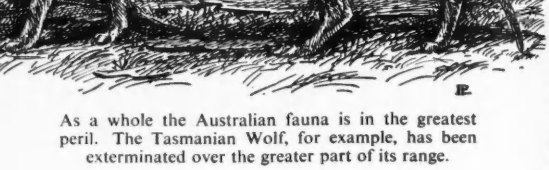
Also in need of protection is the Tasmanian Devil (*Sarcophilus harrisii*), which is the second largest marsupial carnivore. This species too was driven off the Australian mainland by the Dingo, and is now confined to the wilder

Can these Species Be Saved?



As a whole the Australian fauna is in the greatest peril. The Tasmanian Wolf, for example, has been exterminated over the greater part of its range.

The Koala Bear is now fully protected, and there are several sanctuaries in which it is rebuilding its numbers.



The Tasmanian Devil has suffered a fate similar to that of the Tasmanian Wolf, though it is not so rare.

Left.—Wholesale slaughter reduced the number of American Bison from some 50 million to 500. The species has been saved by establishing bison reserves. *Right.*—About a quarter of the 125 forms of Australian kangaroos and wallabies are in danger. This is Grey's Wallaby, otherwise called the Toolach. In 1938 it was thought that only one specimen survived.

parts of Tasmania. Because of the damage it wrought in sheepfolds and chicken-runs, it has been the victim of systematic persecution by settlers.

The marsupial Ant-eaters or Numbats (*Myrmecobius*), of which two forms are recognised, are on the verge of extinction. The West Australian Numbat had no natural enemies among the Australian fauna, and it has proved unable to contend with the cat, dog and fox which the settlers introduced. The extermination of the South Australian or Rusty Numbat Professor Wood Jones considers a tragedy in which man has played very little conscious part. He says that "*Myrmecobius* is an animal which has become highly specialised in function and degenerate in some details of structure. . . . It will not be long before it will be as extinct as those Mesozoic marsupials of the English Jurassic beds of which it has been said to be 'actually an unmodified survivor'."

The marsupial corresponding to the Bear is familiar to all readers: it is called the Koala (*Phascolarctos cinereus*). There are three sub-species, known respectively as the New South Wales Koala, the Queensland Koala and the Victorian Koala. There used to be millions of these native bears, but now few remain.

The New South Wales Koala used to be killed in large numbers by sportsmen and trappers—at the end of the last century, 300,000 koala skins were imported to London, for example, each year. It is now fully protected by law. Incidentally the co-operation of the U.S. Government in protecting this animal deserves record, importation into the United States of koala skins being forbidden about 1930. There are koala sanctuaries near Sydney and Brisbane.

The fate of the other two sub-species has been similar. Both are now fully protected; today the Queensland koala population runs into many thousands, and about a thousand Victorian koalas are left.

Another group of island animals which are threatened is the Lemurs of Madagascar. One form, the Hairy-eared Mouse Lemur (*Cheirogalens trichotis*) has already disappeared. The main reason for this trend is the felling of the forests in which the Lemurs live. A near relative of the Lemurs known as the Aye-aye (*Daubentonia*) is now extremely rare in Madagascar and may be approaching extinction. This, in spite of the natives' reverence for this species, of whom one traveller wrote, they "still believe that the Haihay is the embodiment of their forefathers, and hence will not touch it, much less do it an injury. It is said that when one is discovered dead in the forest, these people make a tomb for it and bury it with all the formality of a funeral."

The story of the European Beaver (*Castor fiber*) brings us nearer home, for this species used to be a native of Britain. By 1188 A.D. it had died out generally in most parts of Britain, though it was still to be found in one river in Wales and one in Scotland. Once upon a time it occurred all over Europe and North Asia; now nearly all the beaver colonies have died out except in a few places in France, Germany, Norway, Poland and Russia. In France, for instance, it has been preserved in sanctuaries; there are said to be some 300 specimens living in sixty to seventy colonies. The disappearance of the Beaver from most of its range is accounted for by the fact that it was hunted for its fur (and also because farmers held it to be a pest); increasing pollution of rivers may also have done much harm.

Two mammals with the 'curse of beauty' on their fur have nearly vanished. These are the European Mink (*Martes lutreola*) and the Russian Sable (*Martes zibellina*). The former has become very rare in France and Central Europe, though there seems less danger that it will become extinct in Russia. The Russian Sable, which resembles the Pine Martin, is more restricted in its range than it used to be, but flourishes in several big reserves in Russia where special 'Sable Farms' have also been created.

It is probably not without significance that the Pine Martin and the Polecat—both near relatives of the Mink and Sable—are much rarer than they used to be in Britain. The former is now found only in the Lake District, the Scottish Highlands and the Welsh mountains; the Polecat is restricted to the Welsh mountains. Another British mammal, whose disappearance followed the clearance of our forests, is the British Wild Cat, now restricted to the wilder parts of Scotland. The European Wild Cat has similarly been extirpated from many parts of its former range; it is now rare in France and Central Europe, its remaining strongholds being in the Balkans.

The wild sheep and the wild horses and asses also appear to be moving towards extinction. For instance, the only truly wild horse which survives today is Przewalski's Horse, the wild horse of Mongolia, and this is now restricted to the steppes of Dzungaria. One species of horse, the Quagga, has become extinct very recently. It was still to be found in the Orange Free State in 1878; the last captive specimen on record is the one bought by the London Zoo in 1851, which died in 1872.

The chief destroyer of the world's mammalian fauna is, Dr. Harper stresses, *civilised man*. He has brought about the extinction of some forms directly, by excessive hunting or poisoning. Others he has wiped out indirectly by invading or destroying natural habitats, placing firearms in the hands of primitive peoples, or subjecting the primitive fauna of Australia and of various islands to the introduction of foreign mammals, including fox, mongoose, cat, rat, mouse and rabbit. "Except in the West Indies, comparatively few species seem to have died out within the past 2000 years from natural causes, such as evolutionary senility, disease or climatic change," is Dr. Harper's damning conclusion.

But if man can destroy, he can also preserve. Amends can be made by the establishment and maintenance of sanctuaries and maintenance of sanctuaries wherever they are needed and with the minimum delay. The problem is probably most acute in Australia, where sanctuaries will need to be made proof against the entry of foxes, rabbits, cats and rats if the smaller Australian mammals—such as the Bandicoots—are to survive.

The Velocity of Light

MODERN physics and cosmology are very much dependent on our knowledge of certain fundamental constants of nature, such as the velocity of light, the gravitational constant, the mass and the charge of an electron, and Planck's quantum constant. Most of these are definitely modern, but two of them have a much longer history. As a conception, the gravitational constant dates from

Newton, while actual determinations of it were made to a reasonable degree of accuracy at the end of the eighteenth century. The velocity of light—*c*—made an earlier début in the sense that the first rough approximations to it were made in the seventeenth century. But if we consider only determinations by methods that would fully satisfy physicists, then its history lies very nearly in the modern period—for the first really satisfactory determination has its centenary this year.

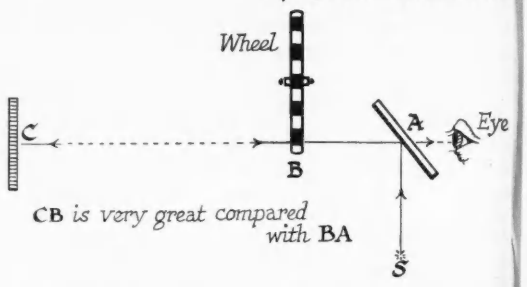
Before 1676 it was a matter of personal choice whether one believed that light was transmitted instantaneously or not. Kepler and Descartes plumped for instantaneity; Galileo, on the other hand, believed that light had a finite velocity, and tried to determine it, using two observers who reciprocally flashed signals to one another. (Needless to say his experiment failed.)

It was by an astronomical argument that Römer, a Dane, first showed in 1676 that light has a finite velocity. One of Jupiter's satellites appeared to be misbehaving. Römer saw that the phenomenon could be explained in terms of the varying time which its light takes to reach us as the distance of Jupiter from the earth varies. He deduced that light takes 11 minutes to cover the radius of the earth's orbit. And this, coupled with the then accepted estimate of the earth's distance from the sun, gave 120,000 miles a second as the velocity of light.

His ideas were confirmed by Bradley's discovery in 1728 of the aberration of light. When the earth is moving transversely to the line joining it to a star, the apparent direction of the star, Bradley discovered, is shifted. This, too, he explained in terms of the finite velocity of light—the apparent change in the star's direction is closely analogous to the apparent change in the direction of the wind when one rides *across* it on a bicycle. Bradley's extremely careful observations gave 8 minutes 12 seconds as the time that it would take light to reach the earth from the sun. This was indeed remarkably accurate, the accepted result now being about 8 seconds larger. He further deduced that the velocity of light is about 10,210 times the velocity of the earth in its orbit.

From an astronomical point of view Bradley's result was excellent—all the astronomer wanted to know was the time from earth to sun, which he could then use to make appropriate corrections to his observed positions. But to the physicist all astronomical determinations of *c* were open to grave objections. To translate them into actual velocities one must know the distance of the earth from the sun, and the methods of determining this distance were both indirect and unreliable. Thus any value of *c* would be based on a longish chain of deductions, with the possibility that a false assumption at some point would invalidate the whole argument. Moreover, with the methods available, the sun-earth distance could not be accurately estimated. Given a correct value of this distance, the astronomical methods would have yielded, even in Bradley's time, a value of *c* in the region of 189,000 miles a second—which is moderately good—but, with the best available estimates, scientists down to the middle of the nineteenth century never did better than 191,000 miles per second—while 195,000 or 'about 200,000' were frequently quoted.

There was therefore urgent need for a direct determination of the velocity of light by terrestrial experiments. Two men, H. Fizeau and L. Foucault, were close rivals for the



THE PRINCIPLE OF FIZEAU'S APPARATUS. Light from *S* falls on a semi-transparent mirror *A*, so that part is reflected to the mirror *C* (about five miles away in the original experiment), where it is again reflected and part of it passes through *A* to the eye. At *B* is a toothed wheel revolving at any chosen speed. A ray which has passed through the gap between two teeth of the wheel arrives back at the same point after the lapse of a definite time. If the speed of the wheel is such that by then a tooth has come to the position of the former gap, no light will be transmitted. Thus by speeding up the wheel until no light is seen, the observer can determine how long light takes to cover the double journey *BCB*. (*From Hogben's "Science for the Citizen".*)

honour of priority. Fizeau got there first in 1849, with the method illustrated in the figure. His first set of experiments gave a value of 195,000 miles per second for *c*. This was, of course, no improvement on the astronomical determinations, but it was the principle that mattered. He had eliminated the chain of indirect argument, so that his figures had a far higher status than those derived from astronomy. And his method and the similar one of Foucault were capable of refinement, and in fact the accurate determinations on which we rely today have been obtained by essentially the same means.

Foucault's apparatus (1850) was somewhat different, being based on the measured displacements of the images of a source of light in rapidly rotating mirrors; the method is derived from one which Wheatstone had used earlier to time the durations of electric sparks. Foucault's determination of *c* gave about 185,000, which is well on the way to the now accepted value of about 186,000. And now the relations of astronomy and physics were reversed—accurate values of the velocity of light, combined with astronomical observations on the same lines as those of Bradley, helped later nineteenth-century astronomers to revise their estimates of the distance of the earth from the sun.

Foucault's method also involved a further advance. Fizeau's experiments had been carried out over a distance of about five miles; Foucault reduced this to three or four yards. Thus it now became possible to determine the velocity of light in any chosen medium. One of Foucault's first experiments (also carried out in 1850) was to show that light travels more slowly in water than in air. Now there were then two possible theories as to the nature of light: it might be a set of fine particles projected from the source, or it might be a wave motion (in a hypothetical ether). Theoretical deductions showed that in the former case the velocity in water should be greater than in air, in the latter less. Thus Foucault's experiment was a crucial test (in so far as any test really can be crucial) which decided in favour of the wave theory.

From Fizeau and Foucault it is but a small step to the

New Discoveries in Pneumaticks! This cartoon by Gillray shows Professor Garnett lecturing at the Royal Institution, assisted by Davy. The founder, Count Rumford, is standing on the right among the audience.

experiment by which Michelson showed in 1881 that the velocity of light does not depend on the earth's motion through the hypothetical ether, and thence to the new facts and ideas on which Einstein's special theory of relativity was based (see "The Commonsense of Relativity" by Dr. S. Lilley, DISCOVERY, March 1949, pp. 74–76). And so we can see in the work of Fizeau 100 years ago and of Foucault 99 years ago the beginnings of one large sector of modern physical discovery.

The Royal Institution (1799–1949)

By the end of the eighteenth century science had reached a stage at which its further progress could no longer be ensured by the efforts of amateurs, however enthusiastic. At least a moderate proportion of whole-time professionals were required. But where were they to find employment? Not in the universities, for these institutions had not yet recognised the promotion of research as being among their functions, and it was little more than a coincidence if a university teacher was also a researcher. There were a few posts for full-time astronomers, since state observatories had been set up largely because states were interested in astronomy as applied to navigation. And hole-in-the-corner opportunities sometimes occurred in medical institutions and the like. Apart from these odds and ends, the first institution in Britain which provided opportunities for men to devote their whole time to science was the Royal Institution, whose 150th anniversary has just been celebrated—on March 7, to be precise.

But the promotion of whole-time research was far from being the original purpose of the Royal Institution. It arose instead from philanthropic attempts to alleviate the sufferings of the poor. Sir Benjamin Thompson, Count Rumford, had become famous in the 1790s for solving in a humanitarian way the problem of the huge army of beggars at Munich. When he came to London his advice was eagerly sought by philanthrophists such as William Wilberforce, the great fighter against slavery, and Thomas Bernard, treasurer of the Foundling Hospital. These three were the main instruments in founding a Society for Bettering the Condition and Increasing the Comforts of the Poor.

Rumford, however, was not only a philanthrophist, but also a scientist, already highly respected for his researches, both pure and applied, in heat. But more than that, he saw a connexion between science and the problem of 'bettering the condition of the poor'. And so he conceived the idea of forming "a Public Institution for diffusing the knowledge and facilitating the general introduction of useful mechanical inventions and improvements, and for teaching by courses of philosophical lectures and experiments the application of science to the common purposes

of life." Early in 1799 he persuaded the 'Bettering' society, and especially Wilberforce and Bernard, to foster this scheme, and at the same time enlisted the support of Sir Joseph Banks, President of the Royal Society. At a meeting held in the latter's house on March 7, 1799, the new institution was founded—to become, after the grant of a Royal Charter, the Royal Institution. A further link with the social movements of the times was the appointment as the first professor of Thomas Garnett, who came from the Andersonian Institution of Glasgow, forerunner of the Mechanics' Institutes.

At first the Institution worked on the lines which Rumford had intended. Progress was made with plans for exhibiting working models, fuel-saving fireplaces and kitchen utensils, establishing courses for mechanics and artisans, and carrying out researches for the further improvement of industrial methods. But soon the Institution changed its form and modified its objectives. The exact details of how it did so hardly matter. For the fact is that although the application of science to bettering the conditions of the poor was a noble objective, an even greater need at that time was the promotion of fundamental research and particularly the provision of opportunities for outstanding men who did not happen to be favoured by the accident of wealth to devote their main energies to research. The managers and the professors (particularly Davy) could not formulate this need in explicit terms, but unconsciously they responded to it. A new constitution of 1810 recognised changes that had already taken place, when it amended the objects of the Institution to include the "promotion of chemical science by experiments and lectures" and the "diffusion and extension of useful knowledge in general". Useful knowledge was always interpreted as including the application of science to practical problems, but it became recognised that ultimately the most useful knowledge is fundamental scientific knowledge from which applications usually flow. The Royal Institution became a place where great scientists pursued mainly fundamental investigations and lectured on fundamental as well as applied science to audiences drawn mainly from the fashionable and the middle-class rather than from the artisans and mechanics. For many years it remained almost the only place in which a man could gain a living by devoting his whole time to science. And even today, amid many rivals, it is still one of the active centres of scientific research.

In the laboratories of the Royal Institution, Davy first reduced electro-chemistry to order, isolated sodium and potassium, established the fact that chlorine is an element and invented (simultaneously with George Stevenson) the miner's safety lamp. Faraday revealed the laws of electromagnetism, discovered benzene, put electro-chemistry on a quantitative basis, and much else besides. And this illustrious line continued through such men as John Tyndall, Sir James Dewar, Sir William Bragg, Sir Henry Dale, and today Professor E. K. Rideal; while others like Lord Rayleigh, Sir J. J. Thomson and Lord Rutherford held chairs at the Royal Institution and helped to further its work, though they did most of their research elsewhere.

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The present head of the Royal Institution, Professor E. K. RIDEAL, delivering a Friday Evening Discourse. These Friday lectures, which start at 9 p.m. precisely and last exactly an hour, are world famous.

The wing span of this Greater Horseshoe bat is 12½ inches. Note the four elongated fingers on each hand, with wing membrane between them.

The Horseshoe Bats

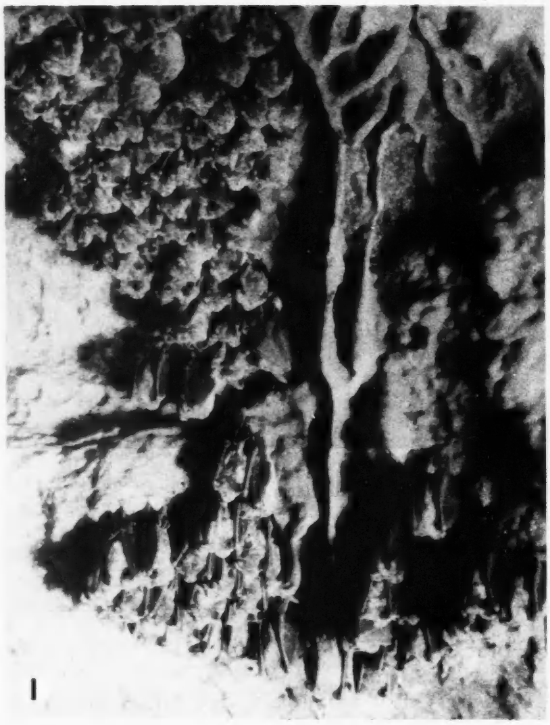
J. H. D. HOOPER, B.Sc., A.R.I.C.

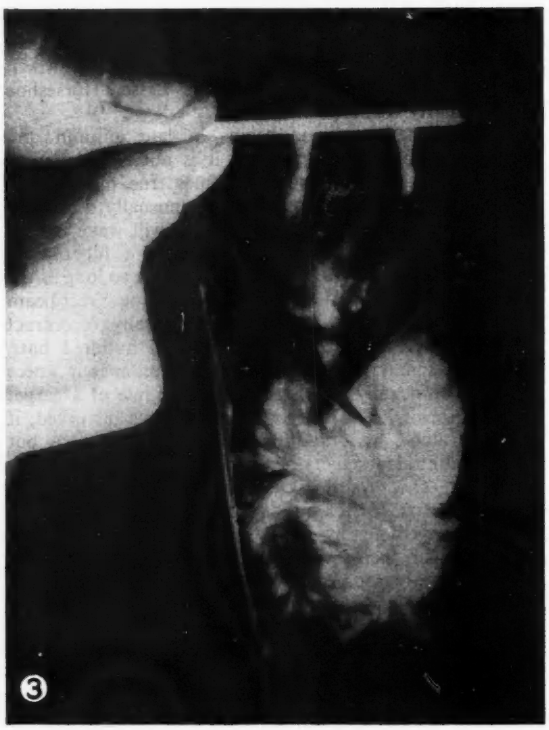
In view of their need for darkness and seclusion in which to sleep and hibernate, it is not surprising that bats frequently choose tunnels and natural cavities for their dwelling-places. The Greater Horseshoe (*Rhinolophus ferrum-equinum insulans*) and Lesser Horseshoe (*R. hipposideros*) bats, in particular, show a marked liking for the underground and are commonly seen in limestone caverns, especially in South-west Britain. In general, they tend to avoid swallow holes or passages carrying active streams, but they are found in a number of the caves which penetrate the Mendip hills in Somerset, and in almost all the limestone caverns that are scattered throughout South Devon. At Buckfastleigh, for example, a small town lying half-way between Exeter and Plymouth, there are about a dozen caves, situated in disused limestone quarries and all lying within a circle, half a mile in diameter. These have long been inhabited by several hundred Greater Horseshoe bats and perhaps a score of Lesser Horseshoes. During the past few years, my wife and I have attempted to learn something of these bats, and the following account is largely based on our observations of this one big colony.

The Horseshoe bats have been described briefly in an earlier issue of Discovery.* Both species are characterised by a curious and complicated leaf-like, nasal structure, whose shape roughly resembles a horseshoe. The wing span of a fully grown Greater Horseshoe can amount to 14½ in., but the average figure is nearer 13½ in. When hanging, it measures about 3½ in. from feet to nose. The Lesser Horseshoe is correspondingly smaller—it has a wing span of 8 to 9 in. and its body is roughly the length of a match stick. The fur of the Horsehoe Bats is composed of almost invisibly fine hairs and is a tawny grey in colour. The wings—silky and delicate—are darker, and when asleep, the bat wraps these tightly round itself like a cloak. In flight, the Horseshoe bats appear silent to the human ear, apart from the beating of their wings, which can be surprisingly noisy in a confined cave tunnel, but when annoyed they will emit an angry high-pitched chatter which is unmistakable in its meaning. The Lesser Horseshoe is particularly vociferous.

The hibernation period begins in late autumn and continues until about April, but it is not easy to judge exactly when normal resting becomes true hibernation. At no time does sleep appear to be unusually deep, and even in mid-winter the Horseshoe bats will wake readily and quickly. Thus, if one stands near a hibernating Horseshoe bat it will take no apparent notice so long as the light is dim, but continued conversation or the direct beam from a torch will cause it to quiver and usually to contract its legs. Sometimes a cluster of several hundred bats, covering a square yard or so, will do a simultaneous 'knees bend'—an uncanny sight, rather like the pile of a carpet lying down of its own accord. A bat thus disturbed, if then left alone, will settle down to sleep once more, but continued human activity nearby will generally cause it to fly away. On several occasions, flash photography of individual bats, carried out at a distance of perhaps 20 ft. from a large colony, has led to the awakening of the entire colony, which then dwindled rapidly, so that within half an hour photographic activities came to an abrupt end due to complete absence of bats! Sometimes, one or two bats would remain behind, apparently as sound asleep as ever, but even these would be found to have gone if the spot was revisited an hour or so later. Next day, the colony would be found in some fresh location, usually in a different cave, a quarter of a mile away or more.

* "The British Bats", by Brian Vesey-Fitzgerald, Discovery, September 1945, p. 277.





THE BATS OF

1. A group of Greater Horseshoe bats hibernating in Baker's Pit Cave, Buckfastleigh. There are over 100 bats in this photo.

2. A Greater Horseshoe bat about to 'take-off'. The claw-like 'thumbs' are clearly visible.

3. This picture of a Greater Horseshoe bat hanging from a matchstick demonstrates the small size and delicacy of the creature's feet.

UCKFASTLEIGH

4. A sleeping Greater Horseshoe bat clings to an insignificant ledge on the cave wall. The interfemoral membrane between the hind legs is clearly seen. This membrane forms a useful umbrella against water dripping from above.

5. A partially awakened Greater Horseshoe bat.

6. Taking a close-up of a solitary Greater Horseshoe bat. The close-ups published here were all taken at a range of between 5 and 7 inches. Illumination was, in every case, magnesium flash.

Although the occasional presence of humans in a cave may well disturb these Horseshoe bats and lead to unwonted activity, winter movement appears to be a normal feature, as they change their hibernating places from time to time of their own accord and are often seen flying outside the caves during the colder months. On the other hand, the solitary hibernators appear to sleep more deeply than the members of a big colony, possibly because, lacking the effect of mutual warmth obtained in a tight cluster, their body temperature falls to a lower level, but possibly also because, hanging alone, they can tuck themselves in small, inaccessible crevices where they are less likely to be disturbed. We have seen bats hanging in fissures barely 3 in. wide—crannies which they enter by running up the wall backwards. They can carry out this movement with great rapidity and also use it when packing themselves into tight clusters.

The Lesser Horseshoe bats in the Devonshire caves are always found hibernating individually, although sometimes quite close to a group of Greater Horseshoes. Many of the Greater Horseshoes also sleep alone, but during cold spells they tend to hibernate in large clusters, packing tightly together in an indeterminate mass of wings, fur and noses. We once counted forty-five Greater Horseshoes on a patch of roof about the size of a single page of DISCOVERY. We have noted with this species of bat that males predominate strongly during the hibernating season, the ratio of males to females being about two to one. Thus, out of 270 Greater Horseshoes examined in Devon between November 1948 and March 1949, only 104 were females (approx 38%). For the Lesser Horseshoes, the discrepancy is not so marked, i.e., 25 males to 18 females, during the same period, but here the total number handled is too small for these figures to have such significance.

Recently, banding experiments were started* in an attempt to find out whether individual bats showed any preference for particular caves. In these experiments, bats found in the caves are captured and details of sex, wingspan, location, etc., are noted; before release, each bat is 'labelled' with a numbered aluminium ring. Shaped like a letter 'C', the ring is clamped gently round the forearm (wing bone), just behind the thumb, care being taken not to damage the delicate wing membrane. These rings are less than $\frac{1}{500}$ of an ounce in weight and cause no inconvenience to the bats. Over 350 bats have been ringed in Devon to date (March 1949) and so far, about 250 'refinds' have been recorded. Some bats have been found again no less than four times and are becoming quite old friends! We have found that during the relatively mild 1948–9 winter, the bats have changed their hibernating places every few days, sometimes even flying between caves a mile or more apart. Also, it seems that as individuals, they show no constancy about their sleeping habits. Thus, to quote a typical example, a solitary bat ringed near the entrance to one cave, was found a fortnight later in the same cave, but in a different chamber and amongst a colony of twenty-three; yet the following week it was found in another cave, 200 yards away, and was solitary once more. On the other hand it does appear that when sleeping together in a big colony, they have certain favourite haunts. Thus in Bakers Pit Cave (Buckfastleigh), which has over a mile of passages, there are about six accepted sleeping places which are used almost exclusively by the big groups, although many other locations in this extensive system would appear equally suitable. One of the chosen spots in fact seems to have little to commend it since it is an area of roof which streams with water in rainy weather so that the bats beneath it becoming soaking wet and very bedraggled.

Sooner or later, the question is asked—how do bats find their way about a cave in pitch darkness? The answer to this has been given by the recent experiments of Griffin and Galambos in America. These workers, using a special microphone in conjunction with an amplifier and a cathode ray oscillograph, have shown that bats use a system, very similar to Radar in principle, to guide their flight. They emit a rapid succession of high-pitched squeaks or 'pulses', the range of frequencies involved varying roughly between 70,000 and 25,000 cycles per second; these sounds are thus inaudible to the human ear. When on the wing, a bat utters some thirty squeaks per second, but the number increases as an obstacle is approached and may rise to as high as sixty per second. These pulses of sound are reflected by cave walls or other obstructions and the echoes are picked up and duly interpreted by the bat which is thus enabled to take the necessary 'avoiding action'. The Horseshoe bats can fly through tortuous cave passages with astonishing skill and we have even known them to pass through slits narrower than their wing span, where they could only fit in by maintaining a permanently 'banked' attitude. On one memorable occasion, however, a Greater Horseshoe bat made a singular error of judgment and flew up inside the trouser leg of an unsuspecting cave explorer who was crawling on hands and knees along a low tunnel!

It has been suggested that the supersonic squeaks of a Horseshoe bat are emitted as a narrow beam of sound through the complex nasal structure, and Vesey-Fitzgerald has pointed out that although it is normal practice for bats to land head uppermost before suspending themselves by their toes, Greater Horseshoes can judge distance so well that they invariably land in an inverted position. This landing process is carried out with such rapidity that it is not always easy to see just what occurs. From our own observations, it seems that they prefer to land on a sloping rather than a horizontal roof; they skim close against this, alighting by carrying out a quick half-roll so that, at the critical moment, the feet grip the rock and they come immediately to rest, head downwards and facing inwards. There seems to be little, if any, slackening in speed before this manœuvre and they rarely miss their hold.

Although it is not too difficult to understand how a bat can use 'echo-location' to avoid obstacles in the dark, it is not so easy to appreciate how it can find its way through a maze of passages and chambers to some predetermined spot—and as evidence that they do make for a definite objective is the fact that the same hibernating places are used year after year. In other words, not only must the bat be able to act on the information obtained from the echoes of its own squeaks, and be able moreover to sort these out from the squeaks and echoes caused by numerous other bats that may be flying nearby, but it must also have some form of 'sound-memory' which it can use for

* This work is being carried out by members of the Devon Speleological Society.

actual route finding through many hundreds of feet of tunnels. It is also of interest that flying up and down vertical shafts presents no difficulty; we once found a Lesser Horseshoe hibernating 40 ft. below the mouth of a sheer pothole, barely 5 ft. in diameter.

At dusk on a summer evening, the Horseshoe bats may be seen wheeling in and out of the Buckfastleigh cave entrances and skimming through the vegetation on nearby limestone crags in search of food. We have found that certain definite feeding-places are used, quite distinct from the hibernacula, and generally located in some sheltered hollow, just inside a cave entrance. Big heaps of droppings, often several inches deep, lie beneath such spots and are liberally strewn with body cases, wings, legs and other indigestible portions of insect material. Such insect remains are rarely found in the droppings underneath the hibernating zones. Cockchafers and various Geotrupes beetles (commonly known as Dor beetles) predominate in the diet of the Greater Horseshoes, while many spiders' legs are found amongst the leavings of the Lesser Horseshoes. Other insects found include Carabid, or Ground Beetles, flies and moths. An insect as large as a cockchafer must form a bulky and awkward meal and would correspond, for example, to a human being attempting to eat an animal the size of a cat! Horseshoe bats, however, have strong jaws and needle-sharp teeth—a fact which we have both confirmed from painful personal experience—and can easily crunch through the hard chitinous body casing of such insects.

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Forest Research—and Alice Holt

UNTIL a few months ago the Research Branch of the Forestry Commission suffered from some lack of concentration, with its officers stationed in London, Oxford, Cheshire and elsewhere. But recently the various specialists—mensuration officer, pathologist, ecologist, entomologist, sylviculturists and so on—have been assembled at Alice Holt, near Farnham; here also are the headquarters of the official census of Britain's woodlands, whose survey has been running for a year and a half but will not be completed for another year. Offices are in Alice Holt Lodge, a small mansion which was the Deputy Surveyor's house when the forest of Alice Holt was enclosed by the Crown in 1812 to provide oak for the Navy.

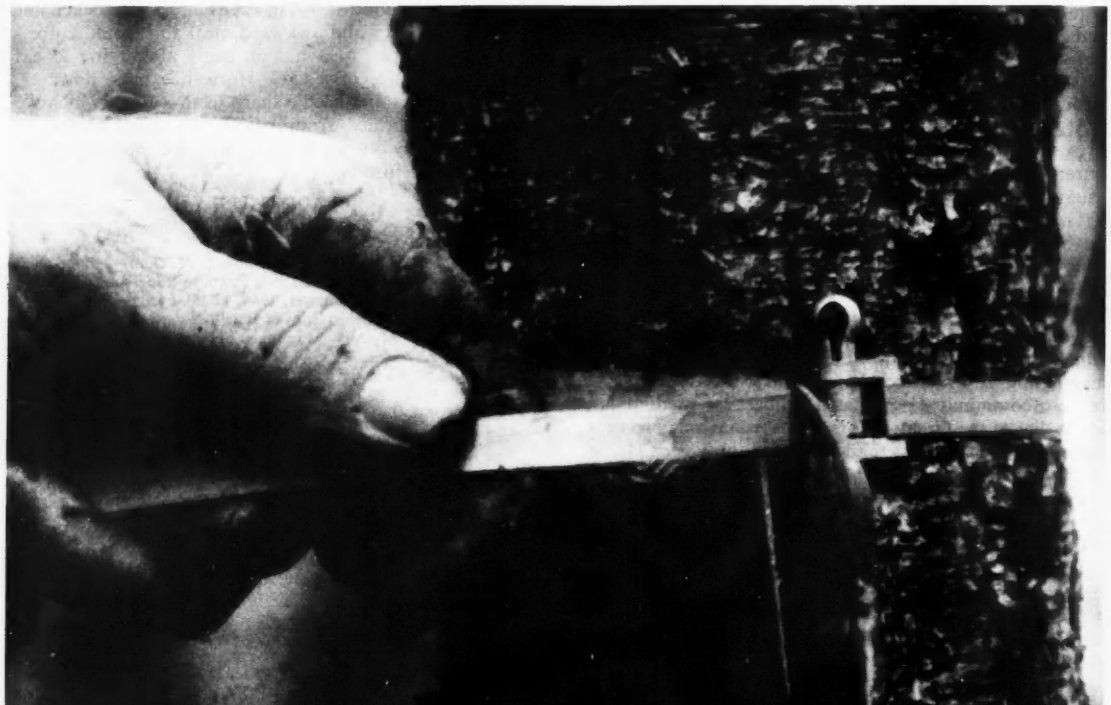
The current research programme includes experiments on seed-testing methods, ways of stimulating seed germination, nursery technique in all its details (with particular emphasis on the maintenance of soil fertility), trials of difficult species, both indigenous and exotic, on the various types of difficult land that the Forestry Commission has to deal with, methods of site preparation, methods of planting, best size and type of plant to use, and study of the raising of mixed crops to settle the question of whether mixtures offer any advantage over pure plantations. Partly overlapping this last subject are tests of various nurse species on difficult ground: for example, common broom seems to prove a most useful stimulant for conifers growing on inhospitable heather moorlands, and Scots pine has shown itself a good nurse of Sitka spruce.

Considerable experimental work has also been done, and continues, on seed provenance for all our more important planted species, and recently several experiments in promoting early seed production have been initiated, partly on Scandinavian models. Techniques include partial girdling, with different types and widths of incision; strangulation with metal bands; root pruning, and grafting on slow-growing stocks in accordance with the fruit-growers' methods outlined (in the days when they were less well-known) by a versifier:

Plant pears for your heirs
Is a saying our grandfathers knew;
But we have learnt since,
If you graft on the quince
The pears will be growing for you.

At present Britain buys much forest tree seed from abroad, and there is not always an adequate assurance of good parentage. Supplies of good seed from élite parents at an early age would be most valuable during the coming years of forest expansion. Incidentally, these experiments on seed production and others, combined with the recent appointment of a geneticist to Alice Holt, suggest that the Forestry Commission are now taking a greater interest than formerly in research into such subjects as seed quality and tree-breeding.

The Alice Holt nursery, which has been licked into shape at remarkable speed by unskilled labour working under the direction of a skilled forester, contains various experiments in the preparation and use of various composts, the effects of new weed-killers, the coverings of seed beds—generally speaking, Bedford sand proves a better cover than soil or sawdust for newly sown tree seeds—and poplar canker. The section of cankered poplars makes a striking contrast with the healthy lines, which include large numbers of young trees imported from Holland. Among other promising varieties there is also a Russian poplar, *Populus berolinensis*. A minor curiosity is some exploratory experiments



An experiment to promote early seed production—a young pine tree being strangulated with a metal band.

in the budding of ash, to test budding techniques. This work is not for use in the forests but might prove valuable to a geneticist studying different types and forms of trees, from which the best might later be selected for organised tree-breeding and seed production.

Of course, very many of the experiments of the Research Branch are located far from semi-suburban Surrey. The chief poplar garden is, for example, at Yardley in Northamptonshire; one high-elevation experiment is going on near Snowdon; there are specialised research nurseries near Oxford, in Dorset and in various places in Scotland; experiments in the effects of deep ploughing in forests before planting have been made from Northern Scotland to Dartmoor; while the sample plots which are regularly measured by the staff of the Mensuration Officer are distributed over the whole of Great Britain. All these and many other activities are the concern of the research officers, some of whom may find themselves on the Culbin Sands one week and in Friston Forest (near Eastbourne) the next.

The forest of Alice Holt itself deserves a brief note. The area slightly exceeds 2000 acres, consists chiefly of clay on gault, at an elevation varying from 230 ft. to 415 ft., and it has a rainfall of about 30 in. Between 1815 and 1825 much oak was planted with an eye to naval needs between 1950 and 2050!—but steel has been preferred since the Battle of Hampton Roads (1862). The proportion of oak was reduced in a working plan made in 1903 by Sir William Schlich, then Professor of Forestry at Oxford, but the Forestry Commission increased the oak area when it revised the working plan on taking over the forest in 1924, and Alice Holt now contains a much larger proportion of oak than most of the state forests. Further, the acreage is likely to be maintained, for this is a hardwood area, and conifers other than Douglas and Corsican pine have not done particularly well. Nevertheless, some interesting natural regeneration of *Thuya plicata* (of which there is at least one excellent stand at Alice Holt) has occurred here, and natural regeneration may also be observed under some Weymouth pines, a few of which have not yet succumbed to the disease that has wiped the species out from most other parts of England. (It is hoped that certain specimens may prove to have some degree of inherent immunity.) Incidentally, the Research Branch has, at Bedgebury, a series of plots of conifers and other species grown under the conditions of forest crops; these plantations adjoin the National Pinetum established by the authorities of Kew Gardens because the smoke of London made the Botanic Gardens unhealthy for many species.

The name Alice Holt is thought by some to be a corruption of Alder Holt, but Gilbert White wrote "Ayles Holt, *alias* Alice Holt" and there is a footnote indicating the occurrence of 'Aisholt' twice in forest rolls of Edward III's reign. The meaning of Aisholt is given in the Oxford Dictionary of Place Names as 'ash copse'. In conclusion, another question is now considered to be closed: Who is this Alice Holt to whom all these men keep going?

Rockets Ahead

CHAPMAN PINCHER, B.Sc.

BRITISH and American authorities have been at some pains to prove that they initiated projects in rocket-weapon development during the last war long before they had any idea of the extent of the German work. Their case is a fair one. It can, indeed, be shown that the small air-to-ground rocket fitted to R.A.F. fighters was actually of greater battle advantage than all the German rocket equipment put together. But at the same time there is no doubt that the array of German rocket missiles discovered after the final collapse—it included more than 100 experimental guided forms—left the Allied scientists goggle-eyed. The fundamental research carried out by German and Austrian scientists on the aerodynamics of fast missiles, guidance problems and liquid fuels has formed the foundation for all such developments now in progress.

Four types of missile seem to dominate the rocket-development field:

(1) The long-range bombarding rocket typified by the V2.
(2) The guided anti-aircraft rocket, of which the German weapon Wasserfall may be taken as the type specimen.
(3) The guided bomb—a straight-fall or winged missile dropped from an aircraft and guided by the aircraft's crew or seeking out its target automatically.
(4) The air-to-ground and field artillery rockets powered by solid fuel such as cordite.

In considering post-war developments along these lines it is convenient to survey the U.S. work first because the Americans have been best fitted to carry on where the Germans left off.

In the first place the United States can afford the scientific manpower and the money to organise research facilities on the grand scale which guided missile development demands. The naval rocket station at Inyokern, 150 miles north-east of Los Angeles, for example, has a staff of nearly 5000, including 500 highly paid scientists and engineers and 100 naval officers. The buildings, spread over about 1000 square miles of desert country, are superbly equipped. Secondly, the open spaces needed for long-range and high-altitude rocket test-flights are readily available. At the White Sands Proving Ground near Las Cruces, New Mexico, and elsewhere, the Americans have thousands of square miles of the type of country not available to Britain outside Australia. Thirdly, the U.S. Government has large quantities of captured German equipment and the cream of the German scientists who built and used it.

It is commonly believed that Russia has obtained the services of the best German rocket brains. This is quite untrue. Long before the Russians reached Peenemunde, Baltic site of the main German rocket range and research station, the technicians had been evacuated with all their movable equipment and records.

The great clear-out from Peenemunde followed a disastrous raid by the R.A.F. on the night of August 17, 1943, when several thousand researchers, military officers and politicians are said to have been assembled there for a special meeting. Some 1500 of them, including the Luftwaffe chief of staff and the commandant of the station, are believed to have perished in the raid. The aerodynamics team was moved to Kochel; the development work was concentrated at Nordhausen and Bleicherode, whilst the theoretical sections went to Garmisch-Partenkirschen. The whole lot was eventually captured by the Americans.

By previous agreement Nordhausen, site of the chief V2 production factory, was to be part of the Russian zone, but the Americans cleared out every completed V2 and shipped them home before the Russians took over.

Details of the equipment and firing records were supplied by the Americans to Britain but not to Russia. After questioning by American and British intelligence officers the technicians who were willing to work abroad—and that was most of them—were shared out. The United States got the pick of the bunch, including Von Braun, Steinhoff and Lippisch. From the remainder Britain chose twenty-three.

The Americans also got the top scientists from the magnificent Hermann Goering research establishment near Brunswick, including Dr. Zobel who did a considerable amount of the specialised aerodynamics research on guided missiles.

Most of these Germans are housed at Fort Bliss, about sixty miles from White Sands, and make the journey to and from the range daily. In less than two years they were said officially to have saved the U.S. Government at least $750 million.

Long-range Rockets

The V2 is now entirely obsolete as a weapon; its restricted range and wide dispersion condemn it. And in any case since its components deteriorate rapidly in storage —the Germans endeavoured to fire each V2 within *three days* of final assembly—the Americans had to use up their stocks quickly.

A programme in which the rockets could be used to yield information of high-altitude conditions essential to the further development of guided missiles was therefore prepared. The universities and industrial laboratories were brought into the scheme and arrangements were made for fundamental research remote from military applications to be carried out with the aid of V2s. This research has covered many fields. Full advantage has been taken of the chance to study the sun outside the lower atmosphere by means of cameras and spectrographs. Measurements of cosmic rays, the earth's magnetic field and the distribution of ionised particles have been made. Recordings of pressure—said to be as low as one-hundred-thousandth of an atmosphere 90 kilometres up—have been obtained.

From steel vacuum bottles, set to open at a certain stage in the rocket's flight and then reseal themselves, samples of air have been obtained for analysis.

A simple and effective method of using rockets to give information of wind velocities at high altitudes has been devised. A smoke generator carried in the nose of a rocket is fitted with a delay fuse to function at any required height. The coloured cloud produced is then followed visually and photographed from the ground. Wind velocities at heights of 200,000 ft.—about 38 miles—have been measured in this way at White Sands.

V2 measurements of temperature tend to confirm theoretical suggestions of peculiar heat changes at high altitudes. Thus at a height of 50 kilometres a recording of 47°C. has been obtained, whilst at 80 kilometres a temperature of −73°C. was recorded. (These are indirect estimates made from pressure readings. Direct temperature measurements above 50 kilometres have not been possible because of the small heat transfer at low air densities.)

Another ingenious method of high-altitude temperature measurement which has been tried is the explosive ejection of small pellets at velocities great enough to make them glow like artificial meteorites. Photographs of their luminosity might provide data from which air density and temperature could be deduced. Pellets have actually been launched in this way but have not been observed so far.

Magnificent photographs covering a sufficient area to show the earth's curvature have high-lighted the possibilities of rockets in geographical and military reconnaissance work.

On the biological side, seeds and fruit flies have been sent up in V2s to discover the effects of acceleration and cosmic rays on living organisms. Both seeds and flies have survived the flights, and the falls. Breeding experiments now in progress will show whether cosmic radiation induced any mutations or not.

The rockets have been fired in an almost vertical trajectory to get maximum altitude, and a height of 114 miles has been recorded. It was not considered worthwhile to arrange for the fall of the V2s to be checked by means of parachutes. Instead, the scientists got as much information as possible by telemetering devices during flight and from instruments armoured against the effects of the impact. The cameras, for example, were enclosed in ¾-in. duralumin and the film was further protected by 1-in. armour plate. In some cases the scientists have found it advisable to arrange for cameras to be blown out of the rocket body at 25,000 feet on the descent.

A parachute designed to function at supersonic speeds has been devised for future experiments. Called the rotochute, it is fitted with vanes which begin to revolve as they encounter denser air. Blown free at the peak of a rocket's trajectory, it can break an instrument's rate of fall to a landing speed of 27 m.p.h.

About thirty of a stock of 100 V2s have been fired so far.

The Americans were quick to realise the importance of fundamental research on the upper air when the Germans proved by their V2 bombardment of London that long-range rocket flight was practicable. So in 1944 they put in hand a project—the Wac-Corporal—specially designed for this purpose.

The Wac-Corporal was a slim, 16-ft.-long rocket powered by a liquid propellant. It reached a height of 43½ miles, and the information it gave was recorded by telemetering devices.

This missile was quickly followed by the Aerobee, a 19-ft.-long two-stage rocket capable of carrying 150 lb. of instruments to a height of 70 miles.

Although essentially a meteorological research tool, the Aerobee has given the Americans useful experience in the design and operation of two-stage rockets. The first stage of the flight is powered by a solid-fuel booster, which takes the velocity up to 1000 ft. per second and then drops off. A liquid-fuelled motor then propels the missile until it reaches a velocity of 4100 ft. per second. A simple device ensures that the impact velocity of the Aerobee is reasonably small. The tail-fin is thrown off during the descent and the consequent aerodynamic instability of the body reduces the velocity to about 150 ft. per second. (The Aerobee was not the first successful two-stage rocket by any means. The Germans had several experimental missiles of this type and they actually fired a *four-stage* weapon called the Rheinbote into Antwerp towards the end of the war.)

According to press reports an improvised two-stage rocket built from a V2 and a Wac-Corporal has been successfully launched from White Sands. The V2 served as an expendable booster, and the Wac-Corporal is said to have gone on alone to a height of 250 miles.

For meteorological work the V2 is, of course, an inefficient instrument. It was designed to carry a payload of nearly a ton, and meteorologists rarely need to send up more than 100 lb. So for the next stage of high-altitude meteorological exploration the Americans have built a modified V2 of similar length—45 ft. long—but designed to carry a much smaller payload and capable of a vertex height of 235 miles. Code-named Neptune, this rocket has new stabilising refinements, but its propulsion system is essentially the same as that of its German parent and uses the same fuels—alcohol and liquid oxygen.

Neptune will not be guided any more than the later models of the V2 were guided. (This was done by an accelerometer integrator which continuously measures the velocity and cuts off the fuel supply when the speed for the required range is attained.) But details and photographs of a partially radio-guided V2-minor—a 32-ft.-long missile known as 774—have recently been released. Again this is not a weapon intended for service but a flying laboratory for future weapon development.

It seems clear that in offensive rocket development the United States is aiming at the production of relatively short-range missiles—up to 500 miles—which could be fired at land targets from warships, including submarines. Army requirements for very long range rockets, like the so-called V4 which the Germans were planning for trans-Atlantic bombardment of America, have been shelved because of lack of fundamental data. (The V4 was to be a winged V2 fitted with a 200-ton booster designed to be jettisoned by parachute at 80,000 ft.)

The biggest rocket yet blueprinted by the Americans seems to be a liquid oxygen–alcohol-fuelled type with a 3000-lb. warhead and a projected range of 500 miles.

There is no doubt that the ultimate aim of offensive rocketry is a weapon capable of delivering an atomic warhead from a reasonable distance. But the weight of the detonating mechanism of the atomic bomb seems to put

AUSTRALIA'S ROCKET RANGE

The new rocket range in Australia—which may be used by the United States as well as Britain and the Dominions—will eventually have a length of about 1200 miles. By firing out to sea a further 1800 miles can be added to the distance over which rockets can be tested.

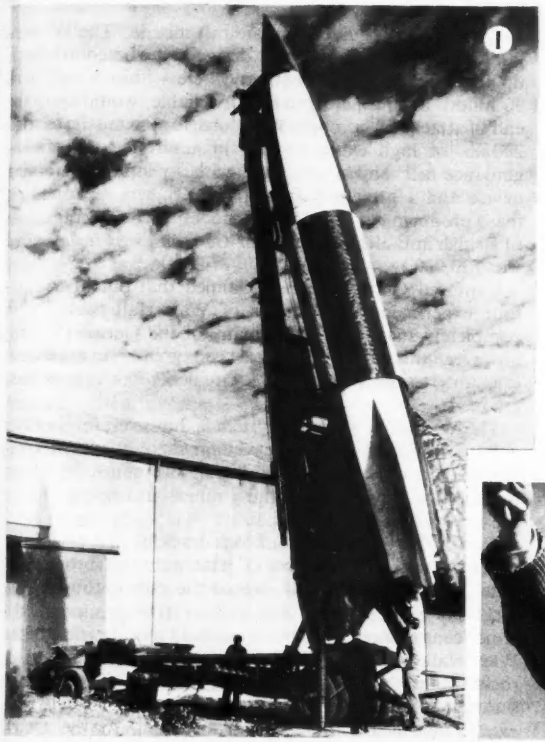


FIG. 1.—A German V2 at the Salisbury research centre.

FIG. 2.—Mr. Bayley, one of the scientists at Salisbury, examines a guided A.A. rocket bomb—known as X4.

FIG. 3.—Lieut.-General J. EVETTS, Chief Executive Officer of the Australian rocket project, discusses plans with Brigadier H. G. EDGAR, superintendent of the Woomera range.

FIG. 4.—DR. W. A. S. BUTEMENT, Chief Scientific Officer at the Salisbury Long Range Weapons research establishment, and his assistant, MR. G. BAYLEY, examine a German Kine-theodolite, which is used to study the flight of a projectile.

FIG. 5.—At the beginning of 1949 the U.S. Air Force announced that it has two guided rockets, the NATIV (North American Test Instrument Vehicle) and the Consolidated Vultee 774. This picture shows the 774 during a test at White Sands Proving Ground, New Mexico, on January 30.

such a development far in the future. The atomic bombs dropped from aircraft have each weighed about 4 tons and whilst research aimed at increasing the explosive efficiency of the bomb has been successful, it does not seem to have been possible to effect substantial reductions in the overall weight. When it is remembered that to carry 2000 lb. less than 300 miles the Germans had to build a rocket 46 ft. long and weighing more than 12 tons at take-off, the engineering of a missile carrying 4 tons at least twice as far is a formidable project.

Guided Ack-Ack Rockets

If the mechanical engineering problems of building rockets are great the electronic-*cum*-mechanical problems of guiding them accurately are enormous. There is no doubt that the difficulties of guiding fast missiles have proved far greater than was anticipated after the early German successes.

It can be seen from the details issued about the 774 rocket that some guidance work is being done in connexion with long-range missile development, but the bulk of it is being applied to the development of relatively short-range A.A. missiles which are a more urgent requirement.

The diagram of the Wasserfall gives some idea of the basic design of a guided anti-aircraft missile. The Wasserfall weighed 3 tons and was designed to be controllable up to a ceiling of 50,000 ft. anywhere within a radius of 30 miles. Such a performance, if reliable, would spell the end of attacks by bomber formations, for the missile carried 200 lb. of high explosive and in addition to its radio-guidance mechanism was fitted with an infra-red homing device and a proximity fuse. The designers reckoned on mass-producing it for £500 a model. (The average cost of British anti-aircraft shells *per German aircraft destroyed* was £20,000.)

Captured German reports claimed that out of twenty-four experimental launchings of Wasserfall twelve were completely successful. Like many of the German claims, however, this seems to have been greatly exaggerated. Guidance to the Wasserfall requirements has not yet been attained.

The Wasserfall guidance system is, however, serving as a pattern for many present developments. It was a command guidance system, i.e. flight was controlled from outside—in this case from the ground—as opposed to the pre-set system of the V2.

Two radar sets were used, one tracking the target, the other the missile. Both lots of data were fed into a computer which automatically steered the missile towards the target by radio signals. This system is being used by the Americans to steer a ground-to-ground modification of the Wasserfall which they call Hermes and a ground-to-air rocket called Nike.

Another system being widely exploited is the *beam-rider system* in which a radar beam 'locks' on to the target, control equipment fitted in the missile keeping it in the beam.

Both methods require micro-wave radar and therefore the earth's curvature limits their range of operation. This range can, however, be increased very considerably by having the command set in a high-flying aircraft. The same limitations apply to missiles fitted with television cameras and guided from a command base on the visual evidence transmitted.

Since all such mechanisms are open to enemy interference, much research is being devoted to the development of homing missiles which seek out their targets independently by means of their own equipment. One possibility is the use of infra-red sensitive devices to seek out and home to an aeroplane's exhaust. The difficulties involved, however, are apparent in the Germans' experience with such a weapon which persisted in homing towards the sun.

Accurate guidance of really long-range weapons seems to be many years away unless some new dependable pre-set systems can be devised. (One possibility is celestial navigation by means of telescopes pre-set on certain stars and feeding information to a built-in computer linked with mechanical controls.)

It should be noted that all the winged anti-aircraft missiles so far developed are *sub*sonic. It would seem, however, that once accurate guidance at subsonic speeds is achieved its application to faster missiles should not be difficult.

Guided Bombs

The Americans had reasonable success during the war with homing bombs operating by means of radar sets fitted

in the nose. They claim, in fact, that such a weapon—the Bat—a flying bomb launched from a plane, was the first fully automatic guided missile to be used successfully in combat.

U.S. designers were also successful with free-fall bombs—code-named Azon, Razon and Spazon—operating on a similar system. The bombardier centred the radar set carried in the bomb's nose on to the target and then released the missile which automatically homed to the objective.

The Germans tried a similar bomb against shipping in south-coast harbours, but it was a failure.

British Research

Post-war rocket research in Britain has been on a small scale so far because of manpower shortages and administrational misfortunes.

Soon after the war ended a Ministry of Supply technical group led by Sir Alwyn Crow, war-time Controller of Projectile Development, in co-operation with the Army carried out firings of German V2s into the sea at Cuxhaven. The three rockets which were successfully launched had all to be built from bits and pieces left by the Americans after their clear-out of the Nordhausen factory. Many missing parts had to be mocked up and since these included the control systems it is not surprising that little useful information was obtained from Operation Backfire, as the Cuxhaven experiment was called. The Government then set up the Guided Projectiles Establishment at Westcott, in Buckinghamshire, to carry out research, design and development of all types of guided missile. Several hundred scientists were to work at Westcott under Mr. W. R. Cook. Unfortunately the original plan has undergone many changes which have seriously curtailed the work, though they may be expected to bring long-term advantages.

As was to be expected, considerably difficulty was experienced in recruiting people with sufficient skill for this new work. Many of the experienced scientists were keen to get out of weapon development at the end of the war, and the salaries offered for the Westcott posts compared badly with those available in industry in spite of parliamentary protestations to the contrary.

From the first there was considerable opposition to the Westcott project from the Royal Aircraft Establishment at Farnborough. With good reason the aeronautical designers claimed that winged missiles came within their field. They also claimed considerable experience of the electronic problems involved in guidance and pointed out the danger that separate research on rockets and supersonic aircraft would lead to duplication.

This point was proved recently by the supersonic flight of the Vickers robot model aircraft. The machine was designed essentially to provide aerodynamic data for piloted aircraft flight at transonic and supersonic speeds. But it was actually propelled by a rocket, and the results obtained are clearly of direct application to the design of winged missiles.

The upshot of the Farnborough opposition was that rocket development was eventually placed under Sir Ben Lockspeiser, then Director-General of Scientific Research for Air, and Sir Alwyn Crow moved to Washington on liaison duties.

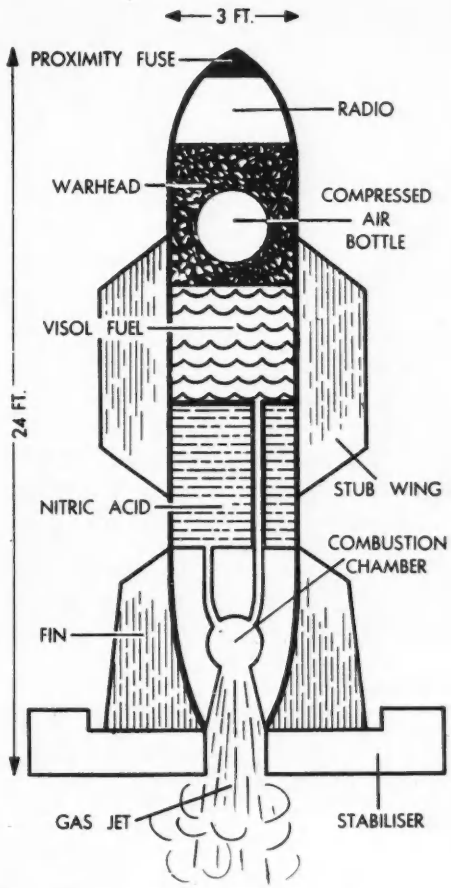
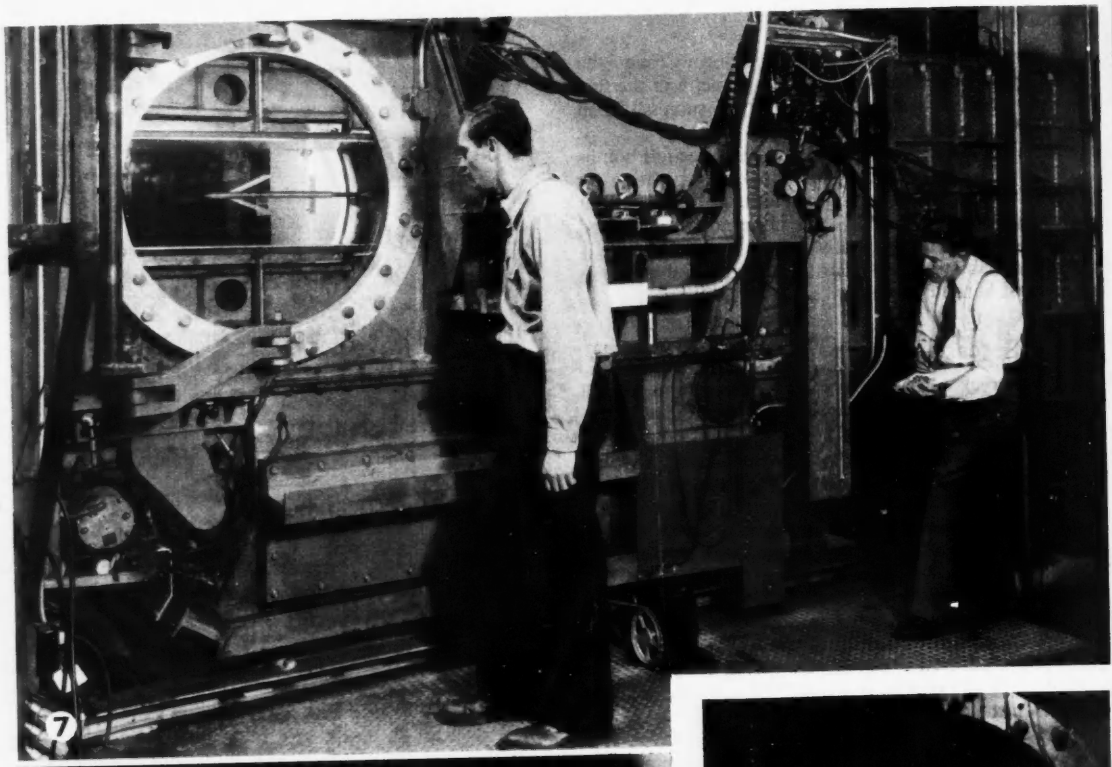


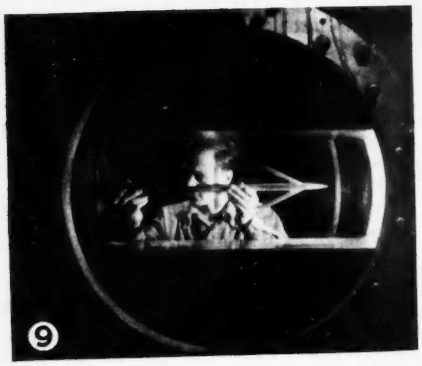
FIG. 6.—The lay-out of the German radio-guided A.A. missile called Wasserfall (Waterfall). Stood on its base and fired vertically like a V2, the missile was powered by a self-igniting fuel mixture. A radio set smaller than a quart saucepan picked up radar signals from the ground which trimmed four stabilisers so that the missile was guided towards an aircraft target. The Germans were convinced that almost 100 per cent certainty could be achieved against aeroplanes and a very high degree of success against rockets.

Within a few months all work on missile design and guidance was transferred to the Royal Aircraft Establishment and its satellite laboratories, while Westcott's responsibilities were restricted to the development of propulsion units.

This arrangement did not satisfy the Admiralty, which has since set up its own establishment at a secret location. Nor did it satisfy Westcott's director who soon left for a more responsible Admiralty post.

Sir Ben Lockspeiser decided to conduct rocket development along the same lines used successfully in the case of military aircraft. The greater part of the development work and some aspects of design are being farmed out to industrial firms, Armstrong Whitworth Ltd. of





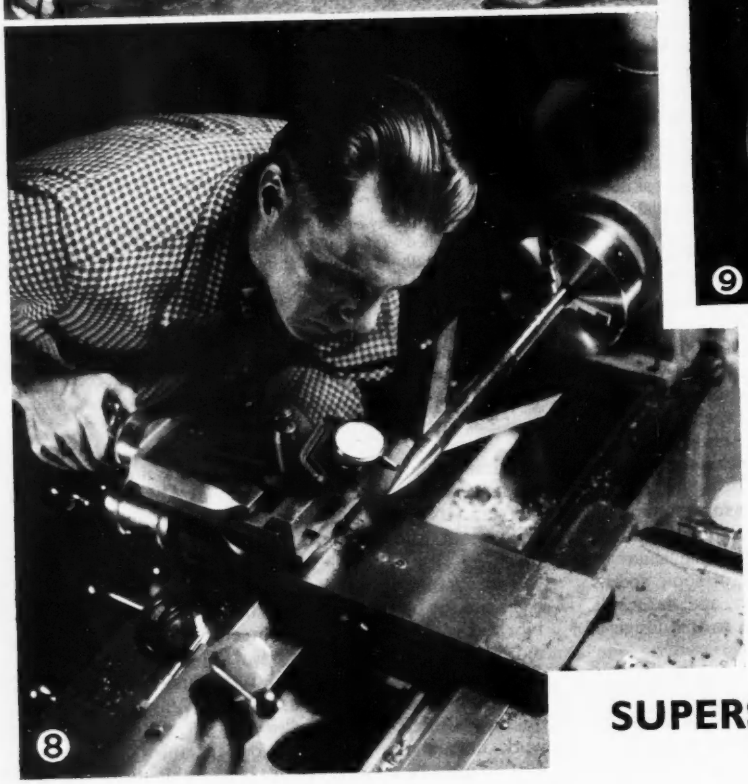


FIG. 7.—Model guided missile undergoing tests at supersonic speed.

FIG. 8.—Checking model for accuracy of construction.

FIG. 9.—Model in position in test section of tunnel.

These six photos show the flexible-throat wind tunnel in use in the laboratory of the Aberdeen Proving Ground.

SUPERSONIC TUNNEL FOR

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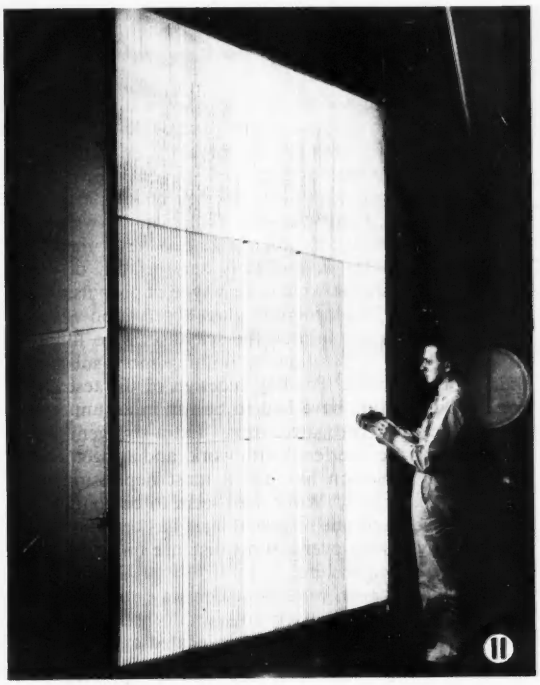


FIG. 10.—The shape of the flexible throat of this wind tunnel is controlled by this machine.

FIG. 11.—Pressures acting on the model in the tunnel are read off this battery of 100 mercury manometers.

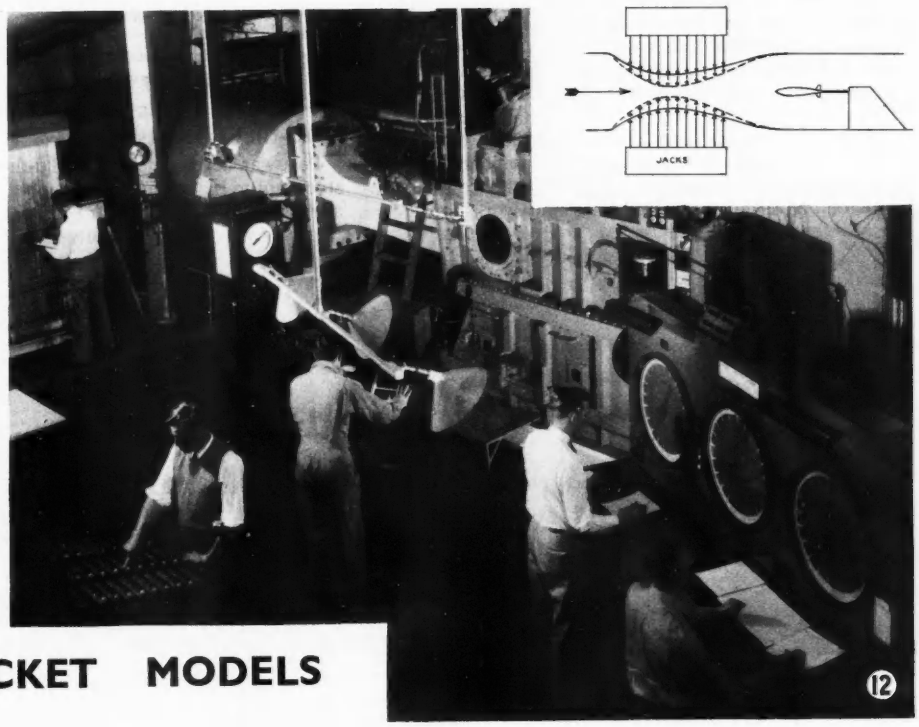


FIG. 12.—General view of wind tunnel. The dials in foreground, *right*, measure lift, drag and pitching moment data. *Inset*, this diagram shows how the shape of the flexible throat is charged by means of jacks; narrowing the throat gives higher Mach numbers.

NEL FOR ROCKET MODELS

Whitley, near Coventry, and the Fairey Aviation Co. in particular.

That work on missiles is now to be expanded in a really big way is shown by the large number of Supply Ministry advertisements for staff at the Royal Aircraft Establishment which have recently appeared.

A piece of bad luck which seriously interfered with progress at Westcott was the explosion in which the German scientist Dr. Schmidt and two other men were killed. Their deaths were directly due to faulty design of the testing chamber in which a new type of propulsion unit was being run. The armoured glass observation windows which blew out and injured the scientists were found to have been held in position by nothing more substantial than short rag bolts. Pending redesign of the test chambers, rocket motors have had to be run in an improvised affair made of corrugated iron. Extra-stringent safety precautions have interfered with work, and altogether that unfortunate explosion has had a most depressing effect on the establishment. Work does seem to be going ahead now, however, and one missile at least has been flown and satisfactorily guided over a short distance on the range at Aberporth, Cardiganshire.

Meanwhile survey work is under way to establish a rocket range which will cover several thousand square miles in Australia. Range-head is located at Woomera—so-named from the aboriginal word meaning "throwing stick"—about 250 miles from Adelaide. As a first step a range about 300 miles long is being built. This will later be extended northwards to a length of something like 1200 miles.

If greater length is eventually required the range will be extended out to sea to cover an overall distance of 3000 miles. Firing pits and observation posts are being built under the guidance of Lieut.-General J. F. Evetts, but the first-priority building project is the erection of a township at Woomera to house 1500 workers and their families.

The huge munitions factory built at Salisbury during the last war is serving as a base technical establishment. Its 1500 buildings cover about eight square miles, and are considered ideal for conversion to laboratories and workshops for guided weapons development. New equipment to the value of £5,000,000 has already been accumulated at Salisbury. Dr. W. A. S. Butement of radar fame is chief scientific officer at the establishment.

It seems clear from published statements that Salisbury is scheduled to become the Empire centre for guided missiles research. Sir Ben Lockspeiser has hinted that supersonic work in general for both aircraft and missiles will eventually be concentrated in Australia.

Walter Units

The hydrogen-peroxide fuel propulsion systems invented by Walter and his team at Kiel are being developed both by the Supply Ministry and the Admiralty.

The Supply Ministry is interested in three main developments:

(1) The use of Walter motors for assisted take-off of heavy bombers.
(2) Their use in very fast short-range fighters of the Me.163 type.
(3) Their use as propulsion units for guided missiles. (It was during the testing of such a unit that the Westcott explosion occurred.)

The Admiralty are chiefly interested in an adaptation of the Walter unit for submarine warfare. Walter and some of his original team are working in the submarine yards at Barrow-in-Furness.

It is understood that the main project is an auxiliary engine to give submarines short bursts of speed up to 25 knots. This would enable them to escape after firing torpedoes and would greatly increase their chances of catching up with fast merchantmen.

The large-scale production of highly concentrated (up to 92%) hydrogen peroxide essential to these developments has been achieved by the Laporte Chemical Co. of Luton.

Solid-fuel Rockets

Post-war developments in solid-fuel rockets are understood not to have been extensive, but some work has gone ahead at Fort Halstead, near Sevenoaks under the guidance

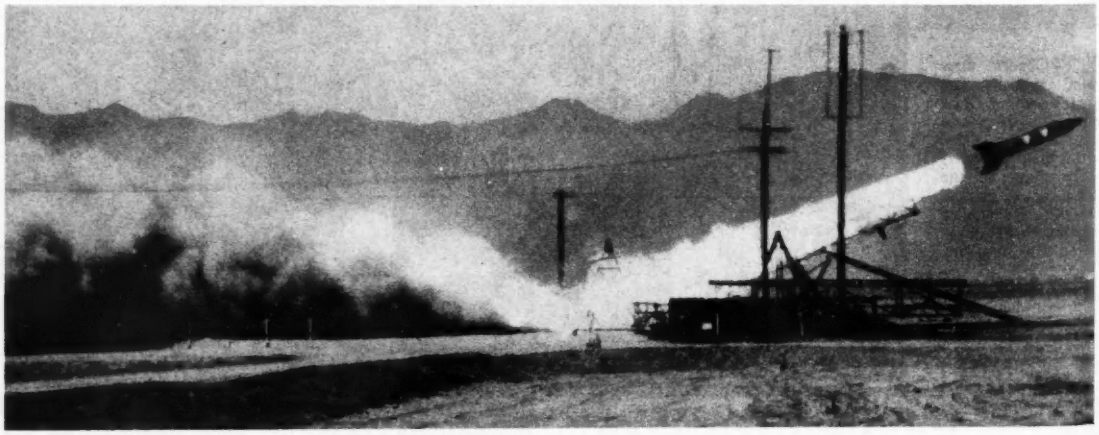


FIG. 14.—This rocket, with a new solid propellant booster, has been flown successfully at the U.S. Naval Ordnance Test Station in California. It was designed for use in launching supersonic missiles, especially those with ram-jet propulsion units.

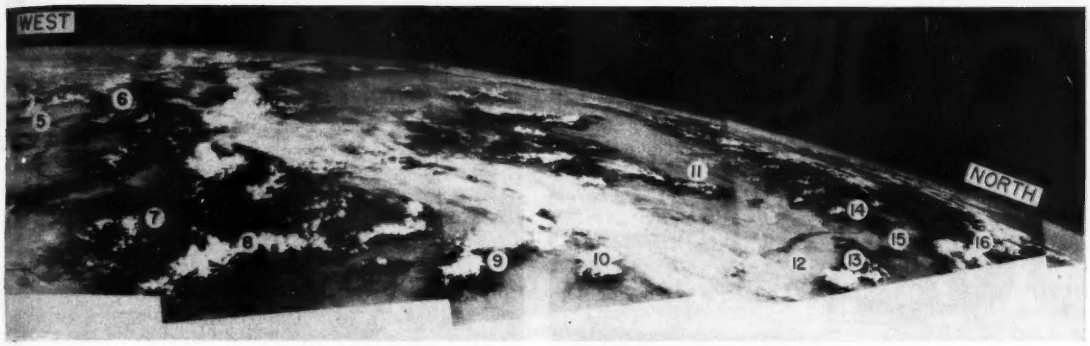


FIG. 15.—Rockets have made it possible to cover a vast area with a single aerial photograph. Above is a mosaic composed of four such photographs taken at 60-miles height from a V2. The base of the mosaic corresponds to a distance of 1300 miles. (*Official U.S. Navy photograph.*)

of Dr. William Penny, Chief Superintendent of Armament Research.

Most of the difficulties of extruding cordite in large sizes and various shapes giving different burning surfaces for special requirements were solved during the war. To restrict the area of the burning surface and thereby produce long times of burning, methods of coating the outside of a charge with plastic or with insulating tape were devised. In this way, for instance, it was found possible to get a solid stick of cordite to burn only on the front surface (like a cigarette), and thus provide a moderate thrust for a long period. Dr. W. H. Wheeler of the Supply Ministry's guided projectiles department has published a suggestion that it may be possible to achieve a similar effect by bonding propellant fillings to the inside of light-alloy tubes.

The use of solid-fuel rockets for air-to-ground strafing, which gives a fighter plane phenomenal fire-power has already been mentioned. The possibilities of similar rockets for air-to-air combats were clearly shown by the German R4M—a 5·5 cm. calibre missile developed early in 1945. In its first operational trial a flight of six Messerschmitt 262s each carrying 48 R4Ms shot down 14 Flying Fortresses and returned to base.

The solid-fuelled rocket with its lack of recoil, relatively light weight and stability in storage is an ideal weapon for pattern artillery bombardment when the requirement is to place as big a concentration of fire as possible on a particular area in the shortest time.

The British "Land Mattress"—a battery of 30 5-in. rocket tubes mounted on a light trailer—did great slaughter in Holland and in the Rhine-crossing. The writer was associated with this development. In spite of impressive field trials the weapon was condemned out of hand by War Office artillery chiefs. Had it not been for the Canadians, who attended the field trials and immediately volunteered to take over the weapon, the project would have been shelved. Captured Germans gave testimony to the tremendous demoralising effect of Land-Mattress fire, and there is no doubt that the artillery rocket has come to stay.

Even more terrifying and revolutionary was the "Sea-Mattress"—a landing-craft fitted with several hundred 5-in. rocket tubes, each firing a 29-lb. shell. The surprise value of a small ship which suddenly launches highly lethal ammunition at a rate of half a ton a second for nearly a minute at a time will be readily appreciated.

Russian Developments

Very little definite information is available about Russian developments in the guided missiles field, but there can be little doubt that the work has high priority in the Soviet Union's military programme.

Russian artillery units made good use of solid-fuel rockets fired in batteries and the much-publicised Katusha weapon is said to have contributed considerably to the defeat of the Germans at Stalingrad.

The German rocket station at Peenemunde fell into Russian hands but, as already stated, most of the worthwhile equipment had been either evacuated or destroyed. Eventually the Russians decided to demolish the station, and a new station is said to have been built in the area of Kiev, which was recently made a prohibited zone for foreign travellers.

Guided missile research is graded 'top-secret', but from a knowledge of the technical problems involved it is possible to predict the limits of development within the next few years.

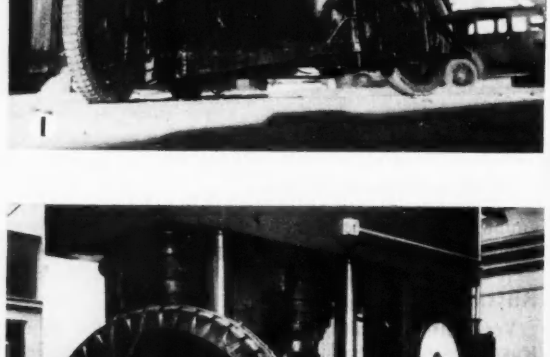
Missiles sufficiently accurate at ranges greater than 500 miles can hardly be available before 1956. Neither, for that matter, can pilotless aircraft.

The fitting of rockets with atomic warheads seems even further away.

In the immediate future then, apart from the already proven devices—the solid-fuelled rockets and the Walter units—the only likely operational developments would seem to be bombarding rockets with ranges up to 500 miles and guided anti-aircraft missiles.

Before guided missiles could be used effectively against Russian targets it would be essential to the attackers to have accurate maps of the country. It seems likely, therefore, that rockets equipped for aerial reconnaissance—telemetering radar maps to a mother aircraft flying high over friendly territory—will have high priority on the U.S. rocket agenda.

(*Readers interested in further technical details of rocket fuels are referred to T. Nonweiler's article "Power Plants for High-speed Flight,"* DISCOVERY, *December, 1946, p. 362, and January 1947, p. 13.*)



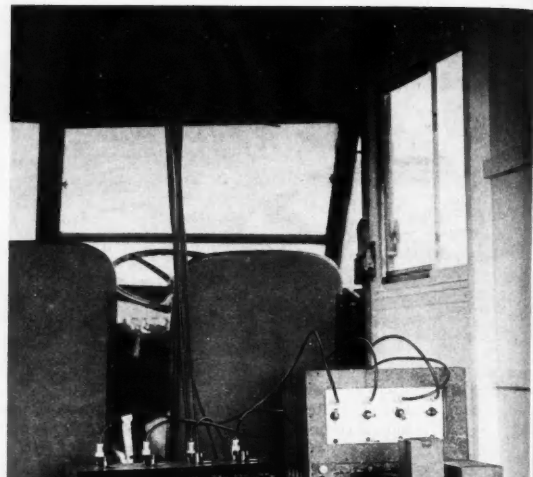
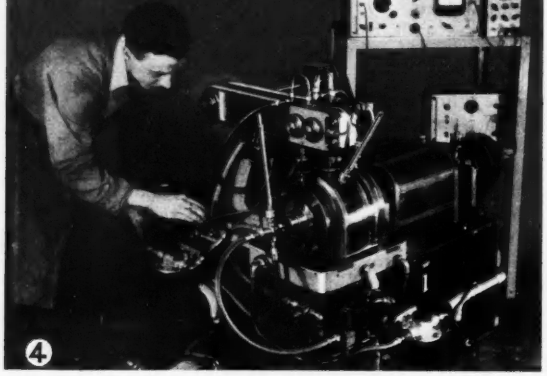


FIG. 1.—The Government's Road Research Laboratory did early work on problems of skidding.

FIG. 2.—The Motor Industry's research association, 'Mira' —descendant of research unit dating back to 1920—was set up in 1946. This Mira apparatus measures strain in wheels under static load.

FIG. 3.—Mira's dynamic-strain recorder installed in a vehicle for road tests.



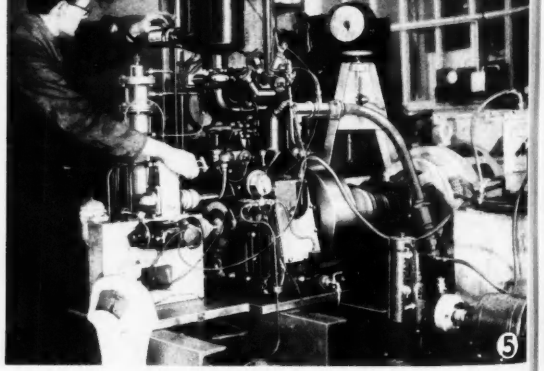


FIG. 4.—This machine at Mira's laboratory is used to study bearings and bearing materials.
FIG. 5.—Research on piston rings is carried out on this single-cylinder test engine.

Automobile Testing on Road and in Laboratory

A Scientific Brooklands

MIRA'S PROVING GROUND OPENS OFFICIALLY THIS MONTH

In Warwickshire, just off Roman-built Watling Street, lies a big, disused Transport Command airfield. Nobody can see it from the lorry-laden road—not even the squatters in some of the huts in one corner, whose view is interrupted by a wood. Gatekeepers and fences keep off those that pry. It used to be called Lindley airfield, and lies a few miles from Nuneaton. On this airfield Britain is in the process of spending a cool million pounds—to better the British motor-car. For it is to be, and is beginning to look like, the first national car-proving ground in the world. Two American manufacturers, Ford and General Motors, have factory proving grounds: efficient enough trial areas, but confined to the products of the firms concerned. But in no other part of the globe should—if plans mature—anything compare with Lindley.

To this proving ground, handy to the car-making centres of Coventry, Birmingham, Luton, and even Oxford, the cars of 1950 and the new-series lorries are already being driven. It is being opened officially this month, though a year or more of work has still to be done before it is completed.

Why all this fuss about testing cars and lorries? Where has it been done in past years, and why cannot it be done in the same place or places? Why spend all this money? Are Britain's vehicles, admittedly all-important as exports for helping to solve the country's balance of payments problem, likely to benefit to an extent justifying the expense? Who pays, anyway? The tax-payer, the manufacturer? First, the expense. The proving-ground project is the brain-child of the Motor Industry Research Association, familiarly known as 'Mira', about which more later. Industry meets two-thirds of the cost of maintaining 'Mira', and the Government pays the rest.

Where has testing been carried out before? It has been done in the lanes of the Midlands, in Scotland, Wales, on the Continent: always it has been done at risk to the drivers and to other road-users, at the risk of accident on public roads. All this has represented expense, not only in the usual ways, but because of breakdowns and the need for repeat trials. Very often trials have not coincided with required weather conditions. It has been a difficult, hazardous, and costly business.

"Granted the need for central test facilities, but why the huge expense? Practically any private park could have been bought and adapted for the purpose," the critic may say.

The answer is that Britain is on the verge of establishing a permanent export market for her vehicles, a market which, with the home demand, may continue to absorb over half a million cars and commercial vehicles every year, and even swallow a still more expanded production when extra steel becomes available. Haphazard testing methods will not do any more. English-built vehicles have not in the future to satisfy merely a few hundred thousand home users every year. They will have to please the world's drivers—even Americans. They will have to bump over cobbled roads, slither through tropical mud, stay on rutted sand tracks, climb mountain passes, and be driven at speed for days and nights together—without showing strain, or straining the drivers.

And all the time the need for higher average speeds, more pulling power, comfort, and greater economy of operation, is developing. Manufacturers know the era of the fast motor road in England, on the Continent, and in other parts of the world, is dawning. If they wish to stay at the top of the exporting list they must build and test, redesign, then build and test again, and repeat the process. So Lindley was born.

I went there to talk to Mr. A. O. Dolby, the Superintendent. At thirty he is keenly conscious of his high responsibility, this ex-captain of R.E.M.E. His office was in the observation room of the control tower left by the R.A.F., and he pointed to the three cars and a lorry already speeding up and down the runways, stopping, restarting and twisting in and out of the concrete aircraft parks off the perimeter track. Next he indicated a plan of the airfield showing the proving ground in embryo form. This plan showed the main runway was reserved for a 2000-yards speed course, divided by painted lines into two speed-lanes, and having timing strips operated by photo-electric cells. The sides of this course were marked at every 100 yards by boards as a warning to the drivers of the amount of braking room they had ahead. On it maximum speeds and acceleration are to be tested.

Next I saw three independent speed circuits were laid out. No. 1 was the 'average speed course', using the 3¼-mile length of the perimeter track; highest average possible is now 60 m.p.h., but banking is to be constructed at some of the bends to allow the average to top 80 m.p.h.—an average speed that should meet requirements for at least a year or two. No. 2 was in the form of a 'W', and No. 3 followed a triangular route; both, using runways, are to allow full test to be made of stability on wet and dry surfaces, acceleration in all gears, braking power and durability. To be laid on the many acres between the runways are test stretches of varying kinds of surface. These include sand, gravel and colonial roads, continental pavé, a bad-condition section and a highly-polished section, a mud splash and water splash, a skid area covered with grease. A narrow, winding, country lane is to be constructed with hedges, using ground outside the perimeter track. Hills? These are to be simulated by cars on test-towing vehicles which are constantly locked in a low gear. My comment, after seeing the plans, was that any car or lorry coming through Lindley with flying colours might certainly beat the world's productions.

Laboratory buildings containing tropical- and cold-storage rooms are to be built. In these cars and lorries will be left exposed to high humidity and heat, or to intense cold. A meteorological office will supply weather data for outdoor-test record purposes. A proposal is even afoot to bring to Lindley all the expensive research equipment at present housed at 'Mira's' headquarters on the Great West Road, near London, and so make the provin gground a self contained 'research university' for the industry. A small town may grow up to house the scientists and engineers who would be resident there.

And 'Mira'? This Research Association is directed by Mr. A. Fogg, a Bolton-born engineer, who is in his fortieth year.

It is the research establishment of the Institution of Automobile Engineers in a modernised form. A Council steers the Research Association, and on this sit twenty members from the Society of Motor Manufacturers, five from the Institution of Mechanical Engineers, five nominated by industrialists and vehicle-operators, and two from the Department of Industrial and Scientific Research.

Eighty men and women form the staff, most of whose work is planned by twenty scientists. There are forty laboratory assistants and skilled mechanics, plus library and office staff. The library have to answer questions coming from all over the world. Its organisation is in two parts—an engineering division with its subsidiary chemistry and physics section, and the information division which provides the main liaison with the industry. Any firm can apply to the information division for advice on a problem, and if the help is not immediately available it can be sought.

Supposing there is no information on record about a particular problem? Then a substantial research committee, which guides several sub-committees, steps in. The sub-committees concern themselves normally with such things as power output, vehicle structure, fuel and lubricants, vehicle performance, instruments, materials, manufacturers' processes, controls, and transmissions. Specialist firms appoint experts to these sub-committees. The job of the parent research committee is to decide which question is to be tackled at once by the technical staff of the headquarters after the sub-committees have reported on the problems.

Problems upon which work has been going on are many and varied. Here are a few:

1. What filtration of oil really achieves. The degree of its necessity.
2. Influence of leaded fuels on exhaust valve failure. What simple remedy is there?
3. Measurements of stresses in different parts of complete vehicles while on the road. (Wire-resistance strain gauges are attached to the components under test.)
4. Corrosion of body panels below the paint.
5. Fatigue strength of crankshafts.
6. Best positions and design for piston rings in engines, to control blow-by, reduce friction and wear, and ensure lowest oil consumption.
7. Compression-ignition engines. To find a satisfactory method of evaluating lubricating oils for these, particularly detergent oils which keep the engines clean by maintaining sludge in suspension.
8. Ventilation of public service vehicles.
9. Gearbox and back-axle performance, plus the heat treatment and oils necessary for the steel from which they are cut.

It is clear that when 'Mira' headquarters move to Lindley, the above list will be lengthened considerably. But British makers should thereby be provided with the know-how of car and lorry manufacture for users in any part of the world.

Here is an impression of the tests in progress as I watched. A Humber Super Snipe was under maximum-speed test with a wheel-type speedometer as trailer. A Humber Hawk dragged a four-wheel-drive ex-Army lorry locked in second gear; object, to take temperature readings at different speeds of the Hawk's engine when under severe load, and so decide the efficiency of the cooling system. An Austin lorry loaded to five tons with concrete blocks roared around in acceleration and speed trials, the test crew afterwards seeming well satisfied with the result. As for me; I had never seen a lorry move so rapidly—it went along rather like an old lady galloping along Piccadilly.

I took part in another kind of test. It was to discover and measure the driver-effort employed to hold a Sunbeam-Talbot 90 saloon on a small circular course at speeds of 20, 25 and 30 m.p.h., on both locks. On its steering wheel a second wheel had been mounted, connected with the first by steel springs. A recording lever on a scale showed the twisting effort in foot-pounds exerted by the driver against the well-known propensity of a moving body to follow a straight path once set in motion.

After a series of hectic circles we found on both locks that the driver had to exert the strength of arm needed to lift 15 lb. to a height of 1 ft. at 20 m.p.h., 18 at 25 m.p.h., and 21 at 30 m.p.h. To cut these figures the steering ratio could be altered. I was not told if the figures were considered high or low. But when next you negotiate mountain passes at best speed do not wonder why you feel temporarily jaded at the end of the pass. W. R.

SCIENCE LOOKS AT DOMESTIC HEATING

THE efficiency of the heating systems in the experimental houses at Abbots Langley has now been determined, as a result of research on house heating carried out by the Building Research Station.

For purposes of the experiment the houses were divided into three groups: *partial heating* (living-room only), *two-stage heating* (background heating with topping-up heating by radiant fires), and *whole-house heating*. Houses in the first group have a wide range of annual input from 950 therms (in a house with an open coke fire and back boiler) to 2,250 therms (in a house with a solid fuel cooker and an open fire in the parlour). The corresponding amounts of raw coal used are $3\frac{1}{2}$–$7\frac{1}{2}$ tons. The whole-house heating group with an average input of 1,250 therms and using $4\frac{1}{2}$ tons of coal are satisfactory when the mean temperatures of the houses are considered.

The two-stage houses, with separate appliances for space and water heating, have a higher thermal input than houses where both space and water are heated by one appliance.

The whole-house systems had an average efficiency of about 70%, the two-stage about 60%, and the partial systems about 50%. All flues were inside the house; with the flues on an outside wall the efficiencies would be 10–20% lower.

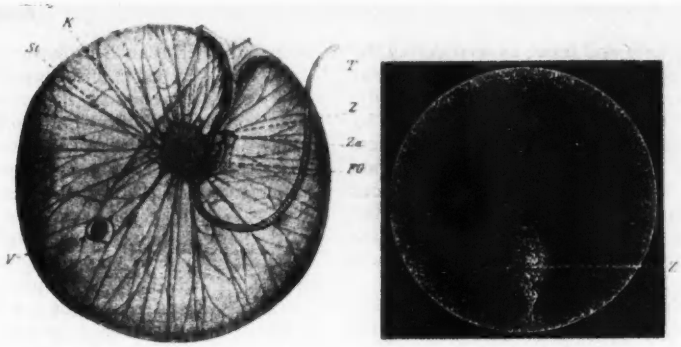


FIG. 1.—The phosphorescence of the sea is due to the minute organism, *Noctiluca*, which is just visible to the naked eye, being one millimetre in diameter. The luminescence comes from small granules, which are seen—in the right-hand drawing—distributed around the periphery of the cell and scattered through the protoplasms; there is a major concentration of luminous granules in the central region *Z*. (*From Harvey's "Living Light", after Pratje.*)

Animal Light

ALAN GOODMAN, M.Sc.

MANY forms of life are capable of producing light. From a single organism the light is dim; forty of the brightest fire-flies give about as much light as a candle. However, the light from a multitude of creatures, as may occur in the sea, is an arresting sight. Ecstatic authors, beginning with Pliny, have written of the 'burning of the sea'. In *The Voyage of the Beagle* Darwin writes, "the sea presented a wonderful and beautiful spectacle . . . every part of the surface . . . glowed with a pale light. The vessel drove before her bows two billows of liquid phosphorus and in her wake she was followed by a milky train." The horizon sky, he says, "reflected the glare of these livid flames".

The faculty of light production is possessed by many organisms—including bacteria, fungi, unicellular animals, sponges, corals, squids, insects and fishes. Curiously, even animals which live isolated in burrows may be luminiscent.

It is interesting to notice that in 1933 a Japanese author claimed to have described and measured luminescence from healthy human tissues. Luminosity was probably evolved separately in modern types, for no other explanation will account for the erratic distribution of this faculty amongst species, and it is the more remarkable that all luminous animals should use the same biochemical—luciferin as the light source.

Living light is 'cold' and is generated efficiently—up to 98% of the energy transformed appears as light. Many ordinary chemical changes are luminescent, and the colour of the light produced is affected by the character of the excited molecule. Luminescence from the reaction between sodium metal and chlorine gas is orange in colour, and is due to the discharge of excited sodium atoms only. Sodium chloride molecules formed may also be excited but not to emit light. Their charge is handed on to the sodium atoms. The synthetic organic substances luminol, and lucigenin have properties similar to the naturally occurring substance luciferin which is the source of the light generated by many organisms. Each of these substances possesses a six-membered ring which undergoes decomposition (by oxidation) with the evolution of light. By the introduction of various chemical groups into the luminol molecule the character of the light evolved during oxidation is changed.

Luciferins from various species differ slightly in molecular structure, variations in the light emitted are possibly due to these molecular differences.

Rachel Dubois in 1886 was the first to demonstrate the fact that luciferin and its associated enzyme luciferase could be isolated from a luminous clam of the genus *Pholas*, and these substances when extracted and mixed together in the laboratory would react to produce light. Luciferin was for many years extracted by hot water, but prepared in this way the luciferin is unstable, and the method has been superseded. A pure product 2000 times as potent (judged by the light generated from it) can be prepared from the dried pulverised bodies of the little crustacean known as *Cypridina*. The material is treated cold with methyl alcohol for a day and from this fluid the pure substance is obtained by successive treatment with *n*-butyl alcohol and ether. The powder prepared from the bodies of *Cypridina* is not luminous when dry and suffers little decomposition during moderate storage, luminous oxidation of luciferin occurring only when the enzyme luciferase and water are present. Formerly it was held that the light of the luciferin-luciferase reaction originated from the enzyme only. This view does not accord with the observation that luminescence is obtained with luciferin dissolved in 95% alcohol at 70°C.; no enzyme would be functional under such physical conditions.

Natural products like tea, coffee, cocoa, ginger, black pepper and even urine, may produce light under the appropriate conditions during oxidation.

Luminescence of bacteria and fungi, as seen during the decay of wood is a continuous process. There is a regular resynthesis of luciferin, and the light is of steady intensity. An interesting use of bacterial luminosity was made by entomologists interested in finding out the regions where oxygen is taken up by the parasitic larvae of Ichneumon flies. The larva was placed in a suspension of luminous bacteria. As the creature depleted the oxygen dissolved in solution, there was a recedence of the luminous area around it. Where larval oxygen absorption was most rapid the luminous region receded fastest.

Luminescent bacteria may invade the tissues of marine crustacea not normally photogenic. In consequence the hosts have been considered 'true' light producers, when in fact they are being parasitised by luminous bacteria, a malady often fatal. The Banda Sea fishes *Photoblephron* and *Anomalops* contain cultures of luminescent bacteria in special sacs near the eyes. The walls of the pouches are ridged with fine blood capillaries thus providing the bacteria with food and oxygen. Similar cultures may be found in some squids. The sac of *Photoblephron* is provided with a shutter enabling the fish to make intermittent exposures of the luminous organ. More remarkable is the luminous sac of *Anomalops*, which is hinged at the corner of the eye. By muscular action the organ can be turned over to expose the luminescent surface. Native fishermen cut out the light sacs of *Photoblephron* and use them as bait for other fishes; the luminosity of the bait persists for many hours. In contrast the light organs of most other bony fishes are glandular. The activity of these glands varies greatly with the mood and general health of the fish.

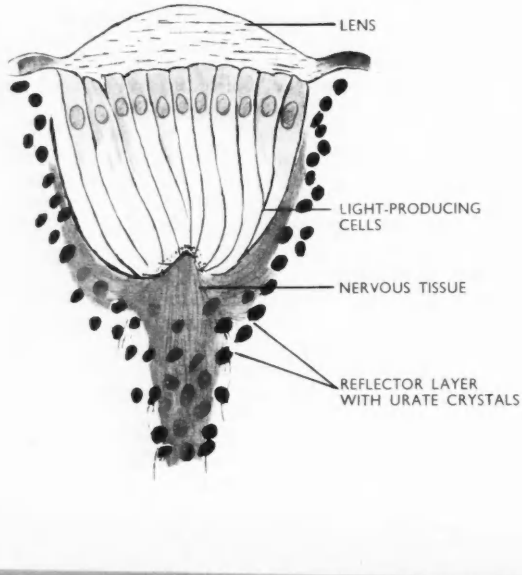
The Sea's Phosphorescence

Phosphorescence in the surface waters of the sea is due to the activity of myriads of crustacea, and of the microscopic protozoan called *Noctiluca*. In contrast to bacteria, these animals produce light only when stimulated to do so by movement of the water near them. Many animals secrete luciferin and luciferase upon their surfaces so becoming sheathed in glistening slime. Dr. William Beebe has recorded mysterious flashes near the window of his bathysphere; these turned out to be due to a small prawn which, irritated by the proximity of the metal globe, showed its disapproval by the rapid 'secretion' of light. The deep-water prawn *Heterocarpus* shoots out puffs of luminescent water to baffle its pursuers; this is of course comparable to the flash phenomenon exhibited by the Red Underwing moth. The larger squids and fishes usually have luminous organs arranged in patterns upon the body. These striking patterns serve as recognition marks between the sexes. In the zone of perpetual night at great depths in the sea some such device must be adopted to serve this end. Possibly also the patterns may act as warning signals to would-be attackers.

Luminous organs vary greatly in structure from the interesting double glands of the crustacean *Cyrpridina* to the complicated bull's eye lanterns of prawns and squids. These lanterns have a reflector layer below the luminous cells. Roofing these cells is a simple lens. In the lantern the active substances are not shed into the water, but the whole reaction occurs within the luminous cells.

Glow-worms and Fire-flies

Insects are amongst the brightest of phosphorescent animals. This is in no small part due to the fact that the light produced falls generally into that zone of the spectrum to which the human eye is most sensitive. Another factor of importance is the ready availability of sufficient oxygen from the air. Sometimes as in certain wingless soil insects, luminous cells are scattered beneath a thin layer of cuticle. In the gravid female of the beetle *Pyrophorus*, a diffuse glow shows over the whole abdomen. This light arises from the yolks of unfertilised eggs which are stored in the oviducts. Generally, however, insects produce light from localised regions upon the under surface, and special attitudes may be assumed by the animal in order to display the light organ to the best advantage. Some distribution



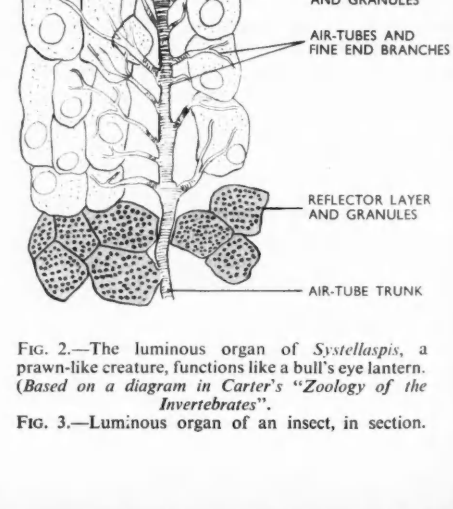


FIG. 2.—The luminous organ of *Systellaspis*, a prawn-like creature, functions like a bull's eye lantern. (*Based on a diagram in Carter's "Zoology of the Invertebrates"*.

FIG. 3.—Luminous organ of an insect, in section.

patterns are shown in Fig. 5 and the detailed structure of a light gland is also illustrated. The luminous cells contain rod-shaped granules which are the actual seat of light production. On the other hand some authors believe the luminous cells to contain luminescent bacteria. This belief is not supported by evidence. These rods or 'bacteria' cannot be cultured outside the body nor can they be transferred from one insect to another. Finally in those insects which are luminous in both the larval and adult stages, excision of the larval light organ does not prevent a new luminous organ arising *de novo* in the adult. This evidence is indicative that the luminous organ is formed entirely from insect tissues and does not contain luminescent bacteria.

The 'reflector' layer contains granules of urates (uric acid salts) and by reflected light it appears white. This layer is presumed to be a reflector, although this has not definitely been proved. A similar layer occurs in the larva of the fly *Bolitophila luminosa* where embedded in it are the rod-like ends of the excretory tubules which in this animal are modified to function as luminescent organs.

Control of Luminescent Activity

The factors controlling activity in luminous organs are poorly understood. It is certain that in most cases luminosity is under direct nervous control. Chemical nerve stimulants such as spider venom, adrenaline and even DDT can cause enhanced luminescent activity. The rhythmic flashing of some insects ceases after decapitation, and may be resumed when the nerve cord is artificially stimulated. Illumination of the head only may cause light production to cease. It would appear, therefore, that the brain of insects has some control over the production of light. Normally the light varies in intensity. Initially the frequency is 300/min it later falls to 150/min, and parallel changes in the discharge activity of the nerve system have been noticed.

It is not known in what way nervous activity modifies light production. Possibly the amount of oxygen reaching the tissue may be regulated, while on the other hand it has been claimed there is control exerted *via* the rate of production of the enzyme. Movement of the muscles adjacent to the luminous organ may stimulate the flow of oxygen into the tracheoles feeding the luminescent tissues. In the beetle *Pyrophorus* green light is given off from the light spots of the upper surface when at rest. In flight, however, the lower surface organs light up a bright orange. The reasons for these

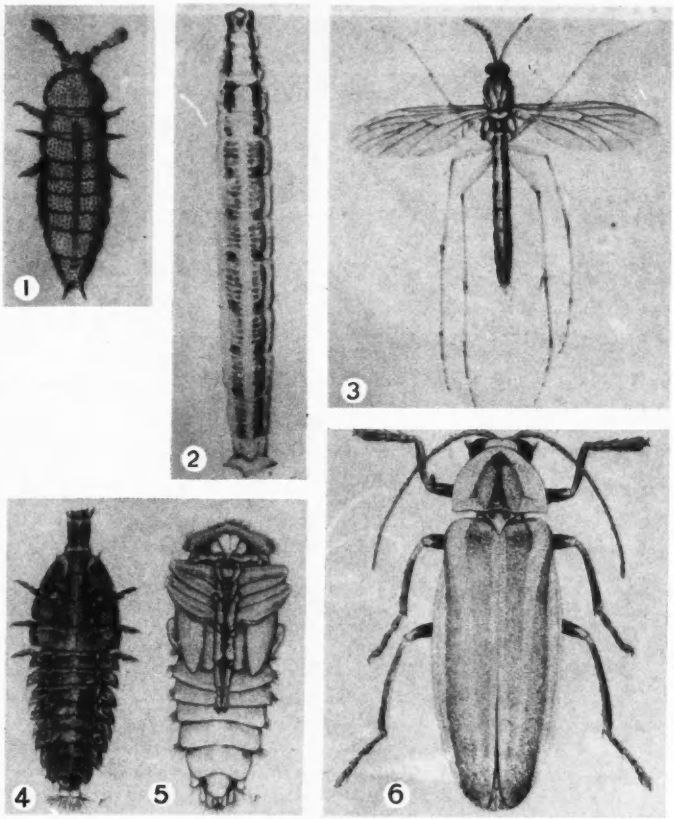


FIG. 4.—A group of luminous insects. (1) A primitive insect (*Lipura*), which is phosphorescent. (2, 3) Larva and adult of a Fungus gnat (*Ceratoplanus testaceus*). The larva is luminous, the adult is not. (4, 5) Larva, pupa and adult of a fire-fly (*Photuris pennyslvanica*), which belongs to the same family as the British glow-worm.

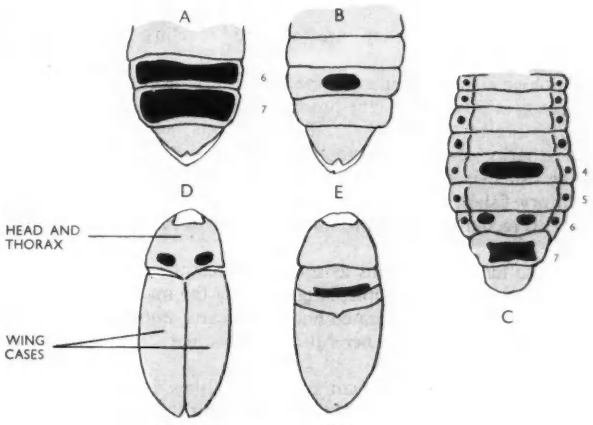


FIG. 5.—These diagrams illustrate the variety of ways in which light organs of insects can be arranged. *A*, *B*, the abdomens of male and female *Photinus*. *C*, the male glow-worm, *Lampyris*. *D*, *E*, dorsal and ventral surfaces of the beetle, *Pyrophorus*.

FIG. 6.—A few luminous creatures of the deep sea. *Top, left to right.* Five-lined constellation fish, angler fishes. *Second row*, luminous squid; the Lantern fish, *Diaphus*; the prawn *Heterocarpus* with its puffs of luminescence. *Bottom*, a small bottom-feeding shark, a sea-squirt, and a glass sponge.

changes and the way they are effected remains in doubt.

The biological significance of the many instances of luminescence is obscure. Light production is often associated with life in the deep sea. The luminous belly of deep-sea sharks probably illuminates the sea-bed over which the fish swims. The luminous organs near the eyes of predatory fishes may serve as lanterns enabling their possessor to recognise objects in the vicinity or to identify the sexes.

Insects use luminous organs as sexual attractants. The female glow-worm, for example, is ignored by the male if she is enclosed within a perforated but opaque box, but she is immediately attractive to her future mate when she is transferred to a glass tube.

Certainly the luminous organ of angler fishes is an efficient lure in the dark world of the ocean depths. However, none of these functions can be attributed to luminescence in the worm *Chaetopterus* which lives buried in mud, or in the clam *Pholas* which bores in chalk deposits. Nor is it clear of what 'use' bioluminescence is to fixed animals like sponges, sea squirts, and corals which feed more or less passively upon the rain of organic debris falling upon the sea bed. Similarly phosphorescence of bacteria, fungi and planktonic animals has no apparent adaptive value. It is interesting to notice that spawning of the marine Bermuda 'Fireworm' is accompanied by flashes of light which are visible for miles. Perhaps these were the 'shore lights' seen by Columbus and his crew on the night they approached the New World.

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The Robot Telephone

THE idea of a machine combining telephone and gramophone which would take messages in the subscriber's absence is nearly as old as the telephone itself. During the past fifty years it has repeatedly left its mark in the dusty patent files of numerous countries.

The first marketable 'telephonograph' was produced in Switzerland in 1946; now this pioneer apparatus has been succeeded by an even more effective instrument, the Notaphone. The Notaphone, which is housed in a metal case no longer than a medium-sized radio set (it measures 20 × 13 × 11 in.), is connected up with any standard telephone instrument without adaptation of the latter or interference with its internal mechanism.

When a call comes through and the phone receiver is not removed after three 'rings' (either because the subscriber is absent or because he wishes to remain undisturbed) the Notaphone automatically comes into action. It first announces the subscriber's name and address, and then requests the caller to speak. If he does not do so after eight seconds, the request is repeated; if he still does not speak, he hears 'Notaphone ringing off', and the instrument suits the action to the word.

As soon as the caller utters the first syllable, the recording mechanism starts to function.

One of the novel features of the Notaphone is the employment of a vocal secret code, pre-set by the subscriber and enabling him, and him alone, to play back the messages recorded on the disc.

By dialling his own number on any telephone, public or private, waiting for his Notaphone's request to speak, and then pronouncing the vowel sounds forming his secret code he sets the reproduction mechanism in motion. An outsider giving the wrong code sounds is informed of the fact and asked by the robot to try a second time, and if this attempt, too, is wrong, the Notaphone voice announces that it is ringing off. A large number of possible code variations (5000 in all) ensures complete secrecy.

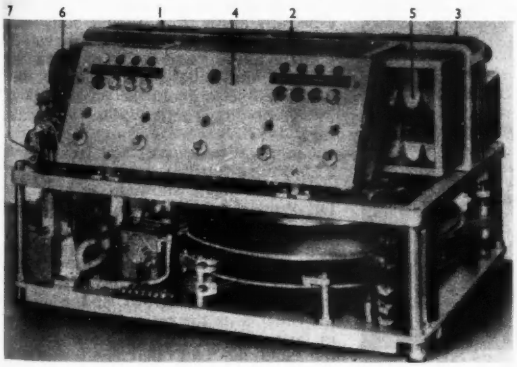
When the subscriber, who is perhaps spending the night out of town, has dialled his number, given the code correctly and been told by his Notaphone that he is now connected, the play-back of the day's 'bag' commences at once. The recording is of such high quality that the play-back is often more distinct than the original, but repetition of an unclear or complicated passage can be obtained if necessary by interrupting the play-back with a protracted *ah* or other predetermined vowel sound.

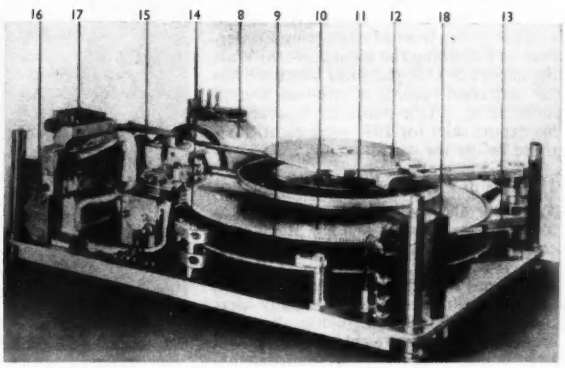
As long as this vowel sound is sustained, the play-back mechanism reverses at two-and-a-half times the forward speed, and resumes at once when the repeat command ceases.

On completing the play-back, the robot requests its master to erase the recording. This is done by pronouncing another predetermined vowel sound, for instance, *eh*, and deletion is verbally confirmed by the Notaphone, which now regains its full half-hour capacity. If deletion is not desired, the recording of later calls on the disc starts where previous recording stopped, and when the instrument's capacity is exhausted the robot voice informs subsequent callers of the fact.

Recording on the Notaphone is effected by means of a disc similar to a gramophone record; but, unlike the latter, it is not scored but merely magnetised when a recording is made. The recording itself can be erased in a second by demagnetising the disc, which is once more ready for use. Since there is neither scratch nor friction of any kind, its life is practically unlimited. Moreover, the twelve-inch disc rotates very slowly during recording and reproduction —only four times a minute—which gives it a 'record' capacity of nearly half an hour.

KURT WALTMANN





(Above) *Inside of Robot Telephone.* (1) *The supply-main section.* (2) *Filters.* (3) *Amplifier, using latest miniaturised valves.* (4) *Control panel.* (5) *Automatic relays.* (6) *Erasing actuator.* (7) *Upper part of plug contacts, fitting over* 17 *in next picture.*

(Above) *The sound-recording and play-back components. The instrument's small size depends on use of magnetic recording disc* (9). *The voice making the various announcements is then recorded on robot disc* (11). *The worm gear* (15) *runs the robot voice and recording discs; and the cam system* (16) *synchronised with robot disc. Magnets* (14) *erase recording. Motor* (8).

Far and Near

Harwell Produces Plutonium

FOR the first time Britain has produced plutonium—this announcement was made by the Ministry of Supply on March 6.

The plutonium was made at the Ministry of Supply Atomic Energy Research Establishment at Harwell, being extracted from a uranium slug which had been irradiated for several months in Gleep, the low-power atomic pile. It was stated that because of the low power at which Gleep operates, the amount of plutonium was small, but it would be sufficient for investigating the chemical and chemical engineering problems to be met in the large-scale handling of plutonium.

Plutonium was first isolated in 1942 in America.

This fissile material was the basis of the atomic bomb dropped on Nagasaki.

Atomic Energy for Ship Propulsion

ADDRESSING a scientific conference on March 17, DR. ROBERT F. BACHER, member of the U.S. Atomic Energy Commission, stated that one of the four new nuclear reactors being built by the Commission will be a land-based model of a unit which it is hoped will be suitable to drive a ship. "It looks as if it would be possible to build a nuclear engine for ship propulsion which would be comparable in weight to the engine and fuel normally carried and which would provide independence in cruising radius," Mr. Bacher said.

The Free Flow of Information

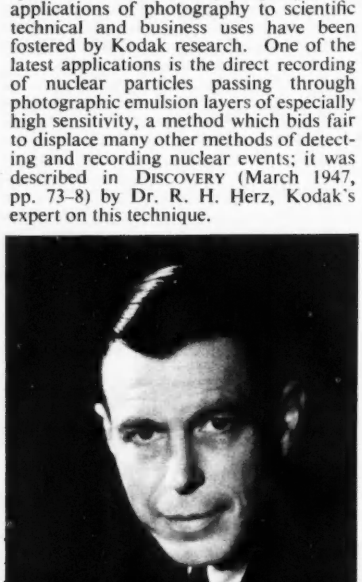
FREER international exchange of technical information was urged by MR. JAMES S. THOMPSON, vice-chairman of the McGraw-Hill Book Company, in an address to the World Engineering Conference. "Following the second World War, the export of U.S. technical literature has far surpassed records of pre-war years," he declared. "One publisher reports that his export sales for 1947 were eight times those before the war."

21 Years of Photographic Research

THIS year the Kodak Research Laboratories in the Kodak factory at Harrow celebrate its 21st birthday.

In 1912 Dr. C. E. K. Mees, F.R.S.—now Vice-President in charge of research for the Eastman Kodak Company—left the old-established Croydon firm of Wratten and Wainwright, where he had been doing pioneer work in photography, to found and direct the research laboratories of the Eastman Kodak Company at Rochester, New York. Kodak Ltd., the British Company in the Kodak organisation, had been manufacturing before the turn of the century, and laboratory facilities had always existed in the factory. Parallel with the rapid growth of the research laboratories of the American concern during the 'twenties, the part of the British organisation was increasingly realised. In 1928 the Kodak Research Laboratories were established at Harrow, under Dr. Walter Clark. Appointed to his position in 1931 on the transfer of Dr. Clark to the American organisation, Mr. E. R. Davies, the present Director of Research, has been in control of the Kodak Research Laboratories since that date. During that period it has expanded from its small beginnings to a large research organisation with a staff of nearly 250.

Kodak research has led to many important improvements in processes, materials and apparatus, and has given much new fundamental knowledge of the photographic process, thus opening the way to further advances in photography. Outstanding achievements of this research have been, for example, the first practicable process of amateur cinematography, and the first process of amateur colour cinematography. Apart from these more spectacular achievements, many important applications of photography to scientific technical and business uses have been fostered by Kodak research. One of the latest applications is the direct recording of nuclear particles passing through photographic emulsion layers of especially high sensitivity, a method which bids fair to displace many other methods of detecting and recording nuclear events; it was described in DISCOVERY (March 1947, pp. 73–8) by Dr. R. H. Herz, Kodak's expert on this technique.



Director of Kodak's research since 1931, Mr. E. R. Davies.

Dirt + Chemicals = Roads

DIRT roads can be converted into hard-surfaced highways by stabilising the soil with plastic materials. This has been known for some years, and the technique was widely employed and well tested during World War II. It was used, for instance, in the construction of military airfields.

The subject was discussed by Dr. HANS F. WINTERKORN (head of the Soil Physics department in the Civil Engineering Department at Princeton University, New Jersey) at a recent meeting of the American Chemical Society.

Chemical treatment of the soil gives surfaces as strong and durable as concrete, he said, and provides a basis for rational construction of cheap roads—particularly in the United States where only 750,000 miles out of a total of 3,000,000 miles of roads can be classed as good. Moreover, the work could have a significant effect on world food production by facilitating development of remote regions, like the area being cultivated under the British Groundnuts Scheme.

There is even a possibility that plastic-treated soil might be employed in building houses, particularly in areas such as South America, where many people build their own homes and thus eliminate high labour costs, he stated.

A phase of soil stabilisation which until very recently was almost totally neglected, according to Dr. Winterkorn, concerns the role played by bacteria in road deterioration. Since bacteria attack some of the plastic materials used in soil treatment, it is necessary to add bactericidal agents to the soil mixture.

With an improved understanding of how bacteria can undermine road surfaces, it has become possible to make use of soil containing large amounts of organic, or vegetable, matter. Normal engineering practice, he pointed out, has been to consign to waste the surface soils possessing the largest accumulation of organic matter and, correspondingly, the greatest biological activity. However, such activity extends even down to the lower layers, which economically cannot be wasted, and especially in the deep organic soils found in the semi-arid western plains of the United States, and in Argentina, the Ukraine, and other parts of the world it is impossible to avoid the problem posed by microbiologic activity, Dr. Winterkorn said.

Comparative tests of soil treated with 2% aniline-furfural resin and 6% of portland cement showed, according to Dr. Winterkorn, that in one type of soil aniline-furfural produced a compressive strength as high as 1273 pounds per square inch, as compared with 470 for portland cement. On another type of soil, the figures were 1124 and 367, and in most of the other tests the ratio was also heavily in favour of the plastic. These statistics indicated, he said, that roads made of plastic-treated soil would compare very favourably with cement highways.

Postgraduate Students can now join S.V.S.

THE Society for Visiting Scientists now admits to membership British Council postgraduate science research scholars and other overseas postgraduate students in science holding research grants, who can be vouched for by an authoritative body, e.g. a Dominion Scientific Liaison Office. Such students will not be full members, but Student Associates, without voting privilege. They will pay a subscription

The Royal Society's New Fellows

This year the following 25 scientists have been elected fellows of the Royal Society:

Prof. John Frank Allen, professor of Natural Philosophy, University of St. Andrews; distinguished for his work in low temperature physics, especially for his discovery of new phenomena shown by liquid helium.

Richard William Bailey, head of Mechanical and Metallurgical Research Department at Metro-Vickers, Manchester; distinguished for contributions on the behaviour of metals at high temperatures and for advances in design of turbines.

Frederick Charles Bawden, head of the Plant Pathology Department at Rothamsted Experimental Station; distinguished for his work on plant viruses and virus diseases, he has also made important contributions to the study of virus serology.

Prof. Francis William Rogers Bramwell, Lloyd Roberts Professor of Zoology, University College of North Wales, Bangor; distinguished for his experimental studies of processes of reproduction in mammals and of the factors concerned in ante-natal mortality.

Prof. Keith Edward Bullen, professor of Applied Mathematics in the University of Sydney; distinguished for work in geophysics, particularly in relation to earthquakes and the distribution of density within the earth.

Dr. Ernst Boris Chain, university Demonstrator in Chemical Pathology, Oxford University; distinguished for his work on enzymes of snake-venom and bacteria, and especially for his researches on penicillin and other antibiotics in which he was associated with Sir Howard Florey. For this work he and Florey were both awarded the Nobel Prize.

Dr. Ulick Richardson Evans, reader in Metallic Corrosion, Cambridge University; distinguished for his researches on metallic corrosion.

Prof. Edward David Hughes, professor of Chemistry, University College, London; distinguished for his researches in the mechanism of the reactions of carbon compounds.

Prof. William Quarrier Kennedy, professor of Geology, University of Leeds; distinguished for his contributions to tectonic geology and petrogenesis.

Prof. William Bernard Robinson King, Woodwardian Professor of Geology, University of Cambridge; distinguished for his researches on the Lower Palaeozoic rocks and on Pleistocene deposits.

Sir Ben Lockspeiser, formerly Chief Scientist, Ministry of Supply, now Secretary of D.S.I.R.; distinguished for his contributions to the development of modern aircraft (*see* Discovery, March 1949).

James McFadyen McNeill, naval architect, John Brown and Company Ltd. Clydebank; distinguished for contributions to naval architecture.

Hedley Ralph Marston, Chief of Division of Biochemistry and General Nutrition, Commonwealth Council for Scientific and Industrial Research (University of Adelaide, South Australia); distinguished for his researches on nutrition and wool growth in merino sheep and on trace element deficiency diseases in ruminants.

Prof. Kenneth Mather, professor of Genetics, University of Birmingham; distinguished for his contributions to genetics and particularly for his studies of polygenic inheritance.

Prof. Peter Brian Medawar, Mason Professor of Zoology and Comparative Anatomy, University of Birmingham; distinguished for his studies of growth processes and the phenomena associated with tissue transplantation.

Walter Thomas James Morgan, research worker, Lister Institute of Preventive Medicine; reader in Biochemistry in the University of London; distinguished for his contributions to the chemistry of immunology and blood groups.

Norman Wingate Pirie, head of the Biochemical Department, Rothamsted Experimental Station, Harpenden; distinguished for his research on the chemical and physical properties of plant viruses.

Prof. Cecil Frank Powell, Melville Wills Professor of Physics, University of Bristol; distinguished for his contributions to experimental physics, especially for his work on the properties of mesons.

David Alymer Scott, research member, Connaught Laboratories, University of Toronto; distinguished for his contributions to the chemistry of insulin, heparin and carbonic anhydrase.

Prof. Wilson Smith, professor of Bacteriology, University College Hospital Medical School; distinguished for his researches on the virus of influenza and on the pathology of staphylococcal infections.

Gordon Brinis Black McIvor Sutherland, reader in Spectroscopy, Department of Colloid Science, University of Cambridge; distinguished for his experimental researches on infra-red and Raman spectroscopy, especially of hydrocarbons.

Prof. Oliver Graham Sutton, professor of Mathematics and Physics, Military College of Science, Shrivenham; distinguished for his researches in atmospheric turbulence and evaporation.

Prof. Meirion Thomas, professor of Botany at King's College, Newcastle-upon-Tyne; distinguished for his researches in plant physiology and particularly for his work on the breakdown of sugar in the plant.

Prof. John Macnaghton Whittaker, professor of Mathematics, University of Liverpool; distinguished for his researches in the theory of integral functions.

Frank George Young, professor of Biochemistry, University College, London; distinguished for his studies of the role of the hormones of the anterior lobe of the pituitary gland in carbohydrate metabolism.

Far and Near—*continued*

of one guinea, and the entrance fee is waived.

The full membership fee remains three guineas per annum, and the entrance fee one guinea.

Inquiries should be addressed to the Secretary, S.V.S., 5 Old Burlington Street, London, W.1.

The Sikhote-Alin Meteorite

Two years ago—on February 12, 1947, to be exact—a giant meteorite fell deep in the Ussuri forests in the region of the Sikhote-Alin Mountains between Khabarovsk and Vladivostok, in Eastern Siberia. An expedition organised by the U.S.S.R. Academy of Sciences has now published its findings on the meteorite. The leader, Academician V. G. Fesenko, believes that the meteorite was an asteroid, and he estimates that its total weight was of the order of a thousand tons.

More than 300 eye-witnesses were interrogated, and many facts elicited. They reported that the head of the meteorite could be observed for some four to five seconds as it travelled across the sky from north to south. It was of an elongated shape, and it appeared to be brighter than the sun. Many sparks of different colours were flying off the head and a dark whirling trail was formed behind, remaining in the sky for several hours. The light inside buildings became perceptibly brighter while the rumbling noise and heavy reverberations accompanying the fall were heard as far distant as 125 miles.

It has been estimated that the temperature of the meteorite after travelling through 90 miles of the atmosphere at a speed of 12·5 miles per sec. must have risen to 5000°C. The meteorite then disintegrated into thousands of large and small fragments which proceeded to fall in a heavy shower of iron on the surface of the earth. It is believed that some 100 tons of these fragments must have fallen in all.

In an oval area of half a square mile there were found over 100 craters. The diameters of these ranged from 0·5 to 28 metres and the depth of the biggest was 6 metres (20 feet). Broken and uprooted trees surrounded them and huge cedars and fir trees had been split apart or pierced by the fragments.

The havoc wrought in the forest illustrated forcibly the interplay of aerodynamic forces which arise during the fall of such a large body. This aspect is being studied in further detail.

The expedition collected some nine tons of fragments ranging individually from a fraction of an ounce to 1·8 tons in weight. These samples of iron of cosmic origin had not yet been disfigured on their surfaces by rust, but all bore evidence of their remarkable journey from interplanetary space to earth. A preliminary analysis indicated the existence of 5·8% Nickel and 0·34% Cobalt in the composition of the meteorite.

This is the first occasion that such

valuable material in this sphere of knowledge is available for scientists to work upon, and the area affected by the meteorite of some 48 sq. km. (19 sq. miles) has been proclaimed a national reserve and has been handed to the Academy of Sciences for five years.

Mullard Market Ultrasonic Generator

MULLARD Electronic Products Ltd. announce the production of the first commercial ultrasonic generator to be produced in this country. It is designed to fulfil the need for an experimental unit of wide flexibility, and its R.F. output is generated directly by a silica triode capable of producing one kilowatt of R.F. power. Four plug-in coil assemblies, which are rapidly interchangeable, are provided for operation around nominal frequencies of ¼, ½, 1 and 2 megacycles.

The generator's quartz crystal is contained in a metal case, and is connected to the generator by means of a co-axial cable. The crystal has silver electrodes fired on both sides, to which the driving voltages are applied. To give the maximum ultrasonic output in the forward direction the generating crystal is air-backed. The limitations on the temperature at which the transducer can work are set by the polythene of the cable and the rubber sealing rings. If silicon rubber is used and the back of the holder is adequately cooled, the crystal can safely be immersed in liquids at temperatures up to at least 150 C.

Inquiries should be addressed to Mullard Electronic Products Ltd., Aboyne Works, Aboyne Road, London, S.W.17.

Defence Research Committee

AT the invitation of the Council of the Royal Society, the Fighting Services and the Ministry of Supply have appointed representatives on a Defence Services Research Facilities Committee, with the following terms of reference:

"*To consider proposals for the use of Service facilities and personnel for assisting scientific research, and to make recommendations to the Council of the Royal Society, the Lords Commissioners of the Admiralty, the Army Council and the Air Council.*"

The Committee has been constituted as follows:

(*Chairman*): Sir Geoffrey Taylor.
(*Royal Society*): *representatives*): Professor P. M. S. Blackett; Sir Harold Spencer Jones; Dr. A. C. Menzies, Mr. F. S. Russell.
(*Representing Admiralty*): Vice-Admiral A. G. N. Wyatt; Mr. F. Brundrett.
(*War Office*): Lieut.-General Sir Kenneth Crawford; Dr. O. H. Wansbrough-Jones (*Scientific Adviser to the Army Council*).
(*Air Ministry*): Air Vice-Marshal C. E. H. Guest, Mr. G. S. Whittuck.
(*Ministry of Supply*): Dr. F. J. Wilkins (*Principal Director of Scientific Research—Defence*); Mr. H. M. Garner.

The Committee conducts its business through panels of scientists and Service representatives who are specially interested in specific projects and at its first meeting panels were formed to cover the following subjects: Submarine Gravity Measurements, Surplus Explosives, Magnetic Survey, Aerial Photography, and Scientific Expeditions.

Scientists wishing to submit proposals for consideration by the Committee should communicate their suggestions in the first instance to the Assistant Secretary, the Royal Society, Burlington House, London, W.1.

Popov and the Invention of Radio

THE Russians celebrated the 90th anniversary of the birth of POPOV on March 16. Popov, according to recent Russian claims, was the inventor of radio.

Prof. Mikhail Shatelen of the U.S.S.R. Academy of Sciences gave these details about Popov in a commemorative speech quoted by *Soviet News*.

"In 1887, when I was in the third year of my university studies," Professor Shatelen said, "I was lucky to be included in an expedition to watch the solar eclipse together with Popov, who at that time was a young scientist. In Krasnoyarsk, where we went, he supervised photometric studies of solar corona and evolved an original method for studying this phenomenon. He devised a photometer which made it possible to assess the luminosity of various parts of the corona.

"But when the expedition ended its work Popov gave up photometry and returned to his favourite subject—electrotechnics.

"Popov was among the first Russian physicists who studied electro-magnetic oscillations. As a result of numerous experiments he designed an atmospheric discharge recorder—a device which is a prototype of all receivers of the spark recording type. In the spring of 1895 Popov demonstrated his remarkable atmospheric discharge recorder at a sitting of the Russian Physical Society at St. Petersburg University.

"I was present at this historic sitting," Shatelen said, "when a telegram was transmitted by wireless telegraph for the first time in the world. Later, in the year of 1900, at the Paris International Congress on electricity, I proudly informed its participants of Popov's invention. I said that his radio installation on the shore of the Gulf of Finland between Kotka and Hogland (a distance of 47 kilometres) proved to be fully workable: 440 official cables, the longest of which consisted of 108 words, were transmitted in the course of 84 days in the winter of the year 1900 when the temperature was 20° below zero.

"I remember that during the discussion which ensued after my report it was noted in particular that the first wireless installation in Russia served as a means for saving 27 fishermen who had drifted out to sea on the ice.

"It is common knowledge that in the past (and frequently at present in foreign countries for that matter) there have been many disputes as to the priority of the invention of radio. However, it has been proved irrefutably with documents that the honour of the discovery belongs to the Russian scientist Popov and not the Italian Marconi."

History of Science

THE British Society for the History of Science is now publishing a bulletin which is edited by DR. S. LILLEY. The first number deals with the foundation and constitution of the society which held its first annual meeting in May 1947.

The society is open to accept new members: the annual subscription is a guinea. Interested readers should communicate with the Society's Secretary at 10 Exhibition Road, London, S.W.7.

Scientific Photographs for R.P.S. Exhibition

THE Royal Photographic Society is holding its 94th Annual Exhibition of Photography at 16 Princes Gate, London, S.W.7 from Friday September 9 until Wednesday, October 26. It will be held in two parts as follows:

Part 1 (Pictorial and Colour); September 9 to October 2, inclusive.

Part 2 (Scientific, Nature, Medical, Record, Press, Commercial, Industrial, Technical and Radiographic); October 8 to October 26.

Entries must be received by July 23. Entry forms may be obtained on application to the Secretary, The Royal Photographic Society, 16 Princes Gate, London, S.W.7, England.

Nature Conservancy for Britain

A NATURE Conservancy for Britain, a nature conservation board with functions comparable in some respects to the administration of Fish and Wildlife Service of the United States, is being set up. This was announced in Parliament by Mr. Herbert Morrison on February 11.

Members of the Conservancy are as follows: Prof. A. C. TANSLEY (*Chairman*); Mr. A. ANDERSON, M.P.; C. ELTON; Dr. E. B. FORD; Dr. H. GODWIN; Mr. E. H. KEELING, M.P.; Mr. N. B. KINNEAR (Director of the Natural History Museum); Mr. E. M. NICHOLSON; Prof. W. H. PEARSALL; Mr. M. PHILLIPS PRICE, M.P.; Mr. J. A. STEERS; Mr. W. L. TAYLOR and Dr. A. E. TRUEMAN.

Director-general of the conservation service which will be organised is CAPTAIN CYRIL DIVER, who operates from offices at Thorney House, Smith Square, London, S.W.1.

In Scotland these nature conservation activities will be directed by Dr. JOHN BERRY, a fisheries expert who has been released by the North of Scotland Hydro-electric Board (who appointed him their biologist in 1944) to join the Nature Conservancy. A Scottish committee will supervise nature conservation in Scotland though the Nature Conservancy is responsible for Britain as a whole, including Scotland. The Scottish committee contains the following members: Prof. J. R. MATTHEWS (*Chairman*); Mr. A. ANDERSON, M.P.; Mr. H. C. BERESFORD-PEIRSE; Dr. F. FRASER DARLING; Mr. A. B. DUNCAN; Dr. D. N. MCARTHUR; Sir BASIL H. H. NEVEN-SPENCE, M.P.; Prof. A. D. PEACOCK; Prof. J. RITCHIE; Prof. JOHN WALTON; Lord WEMYSS AND MARCH and Prof. C. M. YONGE.

The Bookshelf

The Situation in Biological Science

Verbatim report of the session of the Lenin Academy of Agricultural Sciences of the USSR, held on July 31 to August 7, 1948. (Moscow: Foreign Languages Publishing House; pp. 631, British price, 9*s.* 6*d.*)

THE 631 pages of this book contain approximately 48 hours of speechifying. Those unfamiliar with scientific life in Russia may not have realised the enormous part played in that country by long discussions and speeches, which the comrades are obliged to attend.

The participants numbered 700. They comprised "forty-seven members of the Academy, scientific workers from agricultural scientific research institutes and experimental stations, professors from agricultural colleges, the biological institutes of the Academy of Sciences of the USSR, and of the biological departments of the Lomonosov Moscow State University, agronomists, zootechnicians, mechanisers and economists."

Of the speakers, forty-eight belonged to the Marx-Engels-Lenin-Stalin-Michurin-Lysenko axis and eight manifested varying degrees of dissent. Of the eight, only one, Rapoport, could be said to be a pure academic geneticist; one, Nemchinov, was an economist, and a third, Schmalhausen, was—as he said—not a geneticist but an evolutionary morphologist.

Nemchinov, though an economist, took part as Director of the gigantic Timiriazev Agricultural Academy which had laid itself open to criticism by the Lysenko-ites. Stoutly though unsuccessfully he fought for the freedom to differ from the aforesaid sixfold axis. He said: "I observe there is no unity among our scientists on certain questions, and I personally, as Director of the Timiryazev Academy, see nothing bad in this." (Commotion.)

"In our Academy we have sixty departments of different trends and specialities. On the basic question of agricultural science and practice there is complete unity and harmony among us, and I consider that there is nothing bad in the fact that there are certain divergencies, or rather different points of view among us, since these divergencies in my opinion are not fundamental." (Commotion.)

"I consider that the course on genetics should reflect the views of Academician T.D. Lysenko on phasic development. . . . The principles of the chromosome theory of inheritance should likewise not be kept from the students." (Commotion).

Nemchinov refused to budge from what one would have imagined to be a very reasonable attitude, and was dismissed.

Rapoport gave a reasoned defence of the chromosome theory of inheritance, and said: "I cannot agree with those comrades who demand the elimination of the genetics course from the curricula of our colleges and universities."

Academician Zavadovsky complained that those placed (undeservedly) in the category of Weismannist-Mendelists had "not been given adequate facilities to prepare themselves and to give free and full expression to their views." He accused the Lysenko-ites of "creating an atmosphere of premature defamation". He gives the reason why he was classed as a Weismannist and formal geneticist. "It was only done because I repeatedly pointed out, and shall continue to point out, the errors in Comrade Lysenko's work, only because I repeatedly indicated that Comrade Lysenko, while being an innovator in one field, had become a considerable hindrance to many necessary and useful trends in other spheres. But am I for that reason to be defamed. . . ."

The speeches of the forty-eight adherents of the sixfold axis confirmed completely the view that Soviet genetics had gone back to the bow-and-arrow stage. *From now on, Soviet genetics ceases to count.*

The information put forward in this report is a curious mixture of elementary horticulture, wrong-headed breeding technique, special pleading for rational treatment of the land by methods which in other countries are commonplace, and claims which are obviously fraudulent. In fact if you finish up in the right way you can, in the body of your speech, claim as many miracles as you like. You must say things like this about Stalin; "Under the leadership of the greatest genius of modern science, our dear and beloved teacher, Comrade Stalin."

And about Lysenko, "It was said that he is unscientific; innumerable obstacles were placed in his way, but he boldly pushed forward like a true innovator in science, *ignoring everything* (*sic*), militantly vindicated his principles and held aloft the banner of the Michurin trend."

Three of the eight dissentients recanted and were doubtless admitted to the fold. Their speeches make the saddest reading in the book.

S. C. HARLAND.

Proteins and Life. By M. V. Tracey. (Pilot Press, London, 1948; pp. 154, 10*s.* 6*d.*).

THIS is not a popular book about proteins; it is written for people with some scientific knowledge and training, but not expert in the protein field, and it gives sufficient bibliography to be used as an introduction to further study. It is clearly not possible in 150 rather small pages to treat the subject comprehensively, and no selection of topics would satisfy everyone. The theme could have been handled in several other ways but it is unlikely that any of these other ways would have been better than Tracey's.

Most aspects of proteins are at least mentioned. Present sources are described, new ones that are unused or inadequately used are suggested, and brief mention is made of the protein-like synthetic materials. The role of proteins in nutrition leads on to an account of their widespread dynamic relationships in the organism in health and disease and to their appearance as enzymes, antigens, antibodies and viruses. On each point the information is skilfully selected and the explanations are lucid and lively. The whole book is illuminated by a keen appreciation of the historical development of the subject.

It is not possible to praise the publisher as highly as the author. This is an up-to-date book on a rapidly moving subject and so, good as it is, it is ephemeral. It should be rewritten often, and read widely, by students in most sciences, and research workers in many. 10*s.* 6*d.* is an excessive price for a book of 60,000 words, and the high price will greatly reduce sales. Publishers in general seem to have decided that small editions with a large profit are better than smaller profits on larger editions. This may be true financially but it leads to a very restricted dissemination of information and so should not be accepted by the scientific community. It may be argued that the good binding of this book justifies the high price, but only library books need a strong binding and they need a stronger binding than they generally get. For the ordinary reader the paper covers used on Hansard and the Stationery Office publications are perfectly adequate and much cheaper. Most scientific books, especially advanced textbooks, have too long a life. It would be a positive advantage if they fell to pieces before they have become too misleading, for it is a safe assumption that many will sit on shelves and be consulted for as long as they hold together.

N. W. PIRIE.

It should be appreciated by readers that Stationery Office publications are marketed at cost price, and hence it is not fair to compare the prices of official publications with those of ordinary commercial publications. Rising costs of printing and binding (due partly to the increase in price of raw materials and even more to increased labour costs) have made substantial rises in retail prices of books inevitable.—ED.

Ape and Essence. A novel by Aldous Huxley. (Chatto & Windus, London, 1949, pp. 153, 7*s.* 6*d.*)

MR. HUXLEY, who does not seem to care much for the human race, has here written a terrifying forecast of society after the next world war. That war, he says, will be the result of nationalism and an idea of progress which he symbolises in a great audience of well-dressed baboons of both sexes and all ages, gazing attentively at a screen where "in a setting such as only Semiramis or Metro-Goldwyn-Mayer could have imagined, we see a bosomy young female baboon, in a shell-pink evening gown, her mouth painted purple, her muzzle powdered mauve, her fiery red eyes ringed with mascara. Swaying as voluptuously as the shortness of her hind legs will permit her to do, she walks on to the brightly illuminated stage of a night club and, to the clapping of two

or three hundred pairs of hairy hands, approaches the Louis XV microphone. Behind her, on all fours and secured by a light steel chain attached to a dog collar, comes Michael Faraday."

Science is working for the baboon, "comes with the calculus to aim his rockets accurately at the orphanage across the ocean." Two identical Einsteins are enslaved and gassed in the service of opposing ape armies. Kicked, whipped, half-throttled, each of the Einsteins is dragged towards the instrument boards which direct the supersonic missiles. Ape-guided, those fingers, which have written equations and played the music of Johann Sebastian Bach, close on the master switches and, with a horrified reluctance, slowly press them down. . . .

But baboonery, says Mr. Huxley, is also employing brilliant young D.Sc.'s in the preparation of bacteriological warfare, in making such a convenient disease as glanders a hundred-per-cent effective on humans. "Biologists, pathologists, physiologists—here they are, after a hard day at the lab, coming home to their families. A hug from the sweet little wife. A romp with the children. A quiet dinner with friends followed by an evening of chamber music or intelligent conversation about politics or philosophy. Then bed at eleven and the familiar ecstasies of married love. And in the morning, after orange juice and grape-nuts, off they go again to their job of discovering how yet greater numbers of families precisely like their own can be infected with a yet deadlier strain of *Bacillus mallei*." Nor, it should be added, does Mr. Huxley spare the baboon bishops, blessing the baboon marshalissimos and their patriotic proceedings, or those who come rhyming and with rhetoric, to write the baboon leaders' orations. In fact, "Ends are ape-chosen; only the means are man's."

The scientist's reply, through the mouths of the dying Einsteins, that he is not responsible, that he lives only for truth, is not good enough for Mr. Huxley. Pascal, he says, has already explained it: "We make an idol of truth; for truth without charity is not God, but his image and idol, which we must neither love nor worship." So the scientist has lived for the worship of an idol, who, in the last analysis like all idols, is Moloch. That is why the scientist must die in the murderous service of baboons.

Most of the book is in the form of a film-script, and the author's case is argued by the Narrator. After dealing with present-day society, the merciless camera switches to the world found in Los Angeles after the next war by an exploring party from New Zealand, where twentieth-century man has been able to survive. The picture of this Los Angeles society is very far from the Brave New World of Mr. Huxley's earlier imagining. The details are repulsive. The Devil is now worshipped, since it is realised that he is the real director of man. His hierarchy of eunuchs controls a wretched, primitive community, in which women are regarded as vessels of contamination. Babies which are born deformed as a result of past atomic warfare are sacrificed at mass 'purification ceremonies'.

And remember, says the Arch-Vicar of the new society, that even without the atomic bomb, Belial would have achieved all his purposes. For wretched man in thinking himself the Conqueror of Nature, had merely upset the equilibrium of Nature, and would in any case have had to suffer the consequences. He had been "fouling the rivers, killing off the wild animals, destroying the forests, washing the topsoil into the sea, squandering the minerals it had taken the whole of geological time to deposit. And they called it Progress!" Progress and Nationalism—these were the two great ideas Belial had put into men's heads. "The longer you study modern history," says the Arch-Vicar, "the more evidence you find of Belial's Guiding Hand."

It is a gloomy, compelling picture, without pity and without hope. The only flaw is that perhaps mankind is not so hopelessly baboon-controlled as Mr. Huxley makes out. At least mankind is conscious of his ape-like limitations and struggles, however feebly against them, producing sometimes a Christ or a Gandi, or a scientist who, while worshipping truth, does not ignore charity. But the book is written with a moving brilliance which make its arguments doubly powerful. Future generations may consider it the supreme satire of the twentieth century although, if Mr. Huxley is to be believed, it is very doubtful whether they will be interested.

ANTHONY LAWRENCE.

British Flowering Plants. By John Hutchinson. (P. R. Gawthorn Ltd., London, 1948, pp. 374, 22 coloured plates and 174 line drawings. 25*s*.)

DR. HUTCHINSON, a famous authority on the flowering plants of the world, has applied his scheme of classification with striking effect to the British flowering plants and in so doing has illuminated an old and yet ever new subject. He emphasises the importance of the study of the inter-relationships of the plants and he uses evidence drawn from a study of abnormalities. In these respects he is helping to rescue from ill-deserved neglect two lines of thought which have been discredited in the past by the unbalanced enthusiasm of some of their followers.

British Flowering Plants provides a lively account which is very satisfying to a botanist not wholly under the influence of current conventional ideas, but a good working knowledge of British plants, both wild and cultivated, is necessary before the book can be read with understanding. Elementary students will need to use it with caution, students in their final year should find it stimulating. It is very much to be hoped that this and other writings by Dr. Hutchinson may influence both the teaching and the examination of botany and will lead to a more thorough study of flowering plants than is often included in university courses.

Dr. Hutchinson and his colleagues at Kew have prepared some excellent keys to the more difficult families. These keys work well, and they should do much to give encouragement and confidence to readers struggling with such families as the Cruciferae, Umbelliferae and Gramineae.

It is most regrettable that the coloured illustrations do not match the admirable text: some are likely to mislead the inexperienced reader. There is a great need for a really good set of coloured pictures of British plants. The cost of production is certainly a great difficulty, but a publisher might well find it worth while to issue a collection of coloured plates of the common British plants, and of such of the rarer plants which could be shown effectively in colour. A set of illustrations of this kind would help the beginner in botany to gain confidence and to develop the skill necessary to confirm his identifications, by using formal descriptions.

B. BARNES.

The Shorter British Flora. By C. T. Prime and R. J. Deacock. Illustrated by A. Swaffer and A. I. Charlton. (Methuen, London, 1948, pp. 376, 12*s*. 6*d*.)

THIS reviewer is one who, having had no formal instruction in botany, finds the analytical keys in such books as Bentham and Hooker quite unworkable. The use of Prime and Deacock's excellent book, however, has made the identification of flowers so much easier that it can be recommended to nature-lover and botany student alike.

The analytical keys relating to families, genera and species are of the conventional type and depend on the answering of a series of questions about the unknown plant; the questions are, however, invariably easy to answer without exceptional skill in dissection or observation. Thus the presence or absence of milky juice or the colour and size of flowers are details more easily ascertained than, for example, the number of ovules in the ovary—a question often asked in the more difficult keys of other authors. Morphological details which cannot be readily conveyed in words are made quite clear by the copious use of well-drawn diagrams.

The book has been tried out on some 30 species (belonging to about 20 families) and all but one have been successfully traced at least as far as genus; it is mostly in the Compositae or Umbelliferae that doubt about the actual species has been felt. One complete failure only has been found, namely the Bell Heather (*Erica cinerea*) which has only four lobes to the corolla instead of five as required by the key if it is to be successfully traced to its family.

Only very minor criticisms otherwise occur to mind: for example it would improve the book if the glossary were either arranged alphabetically or were to have an index; it would also make things easier for the layman if the everyday rather than the technical term were used where possible as there would then be fewer occasions to use the glossary.

W. F. G.

Printed and Published in Great Britain by Jarrold & Sons, Ltd., Norwich. Editorial Offices: 244 High Holborn, W.C.1.

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William Gregor

an English clergyman, was the discoverer of titanium — a metal of great importance today in the manufacture of paint, pottery, glass and leather. In a valley of his own parish, in Cornwall, Gregor had noticed a black sand with peculiar magnetic properties. This sand is now recognised as "ilmenite", one of the principal sources of titanium. On examination Gregor found that almost half the sand consisted of a reddish-brown solid. Treating this with sulphuric acid, he obtained a yellow solution which, when heated with powdered charcoal, yielded a purplish coloured slag. The slag contained titanium — but Gregor, already a very sick man, was too ill either to carry investigations further or to isolate the pure metal.

The Rev. William Gregor was born in Cornwall in 1762, and educated at Bristol and the University of Cambridge, where he became a fellow of St. John's College and entered Holy Orders. He was always a keen amateur scientist and, though he chose to settle in a remote village of his native county, he quickly acquired a world-wide reputation as a metallurgical chemist through his analysis of such complicated substances as topaz, wavellite and uranium mica. His death from tuberculosis in 1817, at the age of fifty-five robbed him of the satisfaction of seeing the importance of his own work. Nevertheless, his work on titanium gives him a place in that select band of British chemists to whom the world owes the discovery of important elements.

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